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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 87, No. 1, pp. 1–20 JANUARY, 1960

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TWO NEW MEMBERS OF THE ACRASIALES

LINDSAY S. OLIVE AND CARMEN STOIANOVITCH[1]

The first isolation of a cellular slime mold in this study was made by the junior author in the laboratory of Dr. Samuel Bell, allergist, in New York City. The isolation was made from dry florets of *Phragmites communis* Trin., the most common large marsh grass in our area, in an attempt by Dr. Bell to determine whether some fungus growing on the grass might be the cause of an allergy in a patient. The inflorescences had been picked from a clump of the grass growing in a yard in Somerville, New Jersey. This particular clump had been transplanted from the owner's yard in Pittsburgh, Pennsylvania. These inflorescences had been kept in the house for over a month as a decoration, after which (November, 1958) some of the material was brought into Dr. Bell's laboratory. Here it was kept in a plastic bag at room temperature until February, 1959, at which time the platings were begun.

In making a plating, a few fruiting florets were removed from the inflorescences and placed in a test tube of sterile distilled water, the contents agitated for a short period and then poured over plates of Difco cornmeal-dextrose agar to which 0.2% yeast extract had been added, in addition to 2 antibiotics to reduce bacterial growth. Four mg. of streptomycin and 20,000 units of penicillin were added for each liter of medium. Within several days after plating, numerous colonies of fungi, representing a number of different species, had appeared, in addition to some bacteria. Among this growth were noted several unusual pink structures with branching spore chains. Closer examination revealed that the organism was a member of the Acrasiales and a species of the little known genus *Acrasis*. It was isolated on fresh medium along with a pigmented bacterium.

In March, 1959, a second plating of the same material was made, and this time the *Acrasis* reappeared along with a second organism, apparently undescribed, which is probably one of the simplest members of the Acrasiales. The latter was readily detected by its single spores produced at the tips of narrow tapering stalks. Both organisms were isolated together with their common associate, a pink yeast, and were later separated. In late March, a second collection was made from the same *Phragmites* plants, this time from inflorescences lying on the ground. Again both species of Acrasiales were isolated on the pink yeast. Collections of upright and

[1] The authors are grateful to Miss Edith Cash for the preparation of the Latin descriptions, and to Dr. Samuel D. Bell for his cooperation and interest during this study.

[THE BULLETIN for November–December 1959 (86: 367–446) was issued December 23, 1959.]

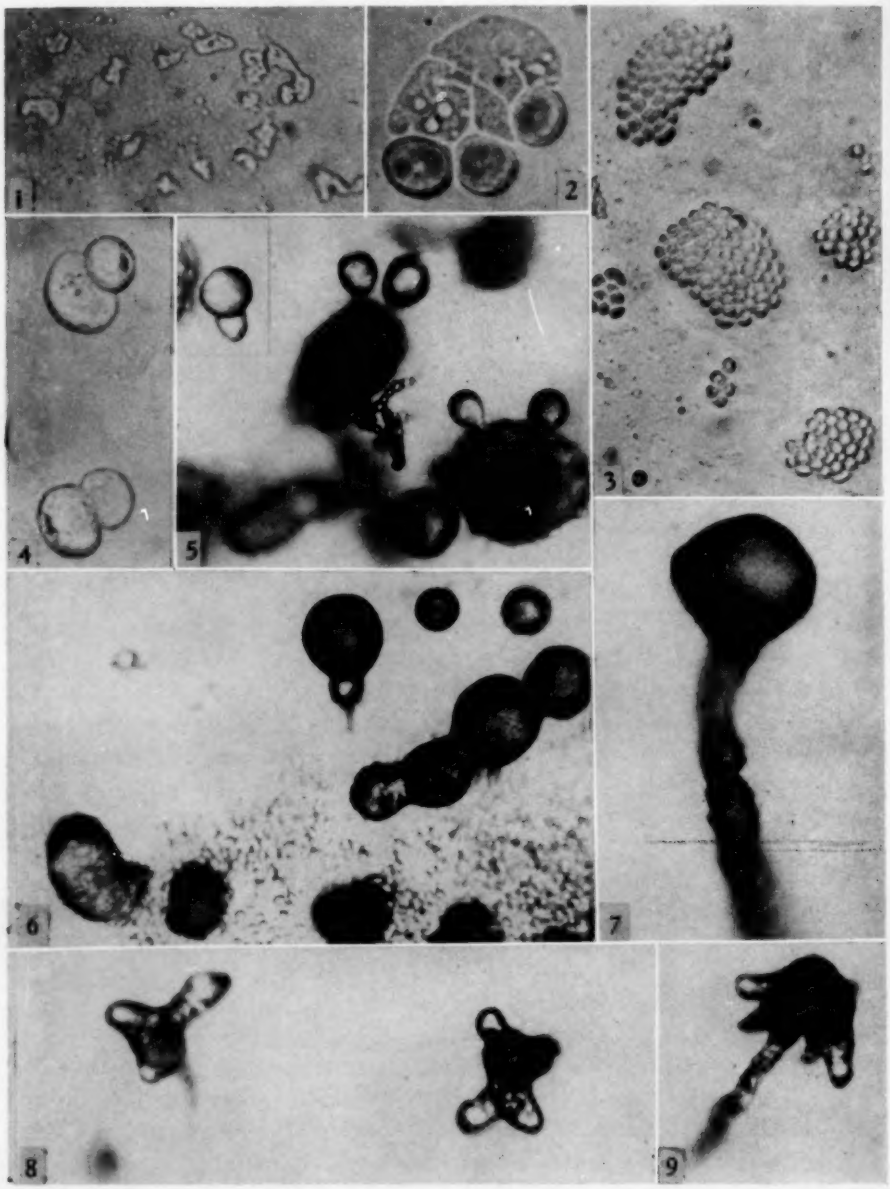


FIG. 7. Globular sorogen and many-celled stalk. × 160.—FIGS. 8, 9. Lobed sorogens. × 160. drop culture. × 190.—FIG. 2. Myxamoebae and microcysts on agar surface. × 640.—FIG 3. Groups of microcysts in hanging drop culture. × 190.—FIG. 4. Encysting myxamoebae. × 640.—FIG. 5. Pseudoplasmodia on *Phoma*. × 160.—FIG. 6. Pseudoplasmodia on culture of *Rhodotorula*, arising from large group of microcysts. × 160.—FIG. 7. Globular sorogen and many-celled stalk. × 160.—FIGS. 8 and 9. Lobed sorogens. × 160.

fallen inflorescences of *Phragmites communis* and of an *Andropogon sp.* growing wild in the Somerville area failed to yield either species, as did *Phragmites* collections from other areas of eastern New Jersey. We also failed to isolate these organisms from several unidentified dead grasses and ferns and several *Phragmites* collections in the area around New York City. However, a single *Phragmites* collection obtained at Jones Beach, Long Island, on May 28, 1959, yielded the *Acrasis,* this time in association with a culture of *Phoma.*

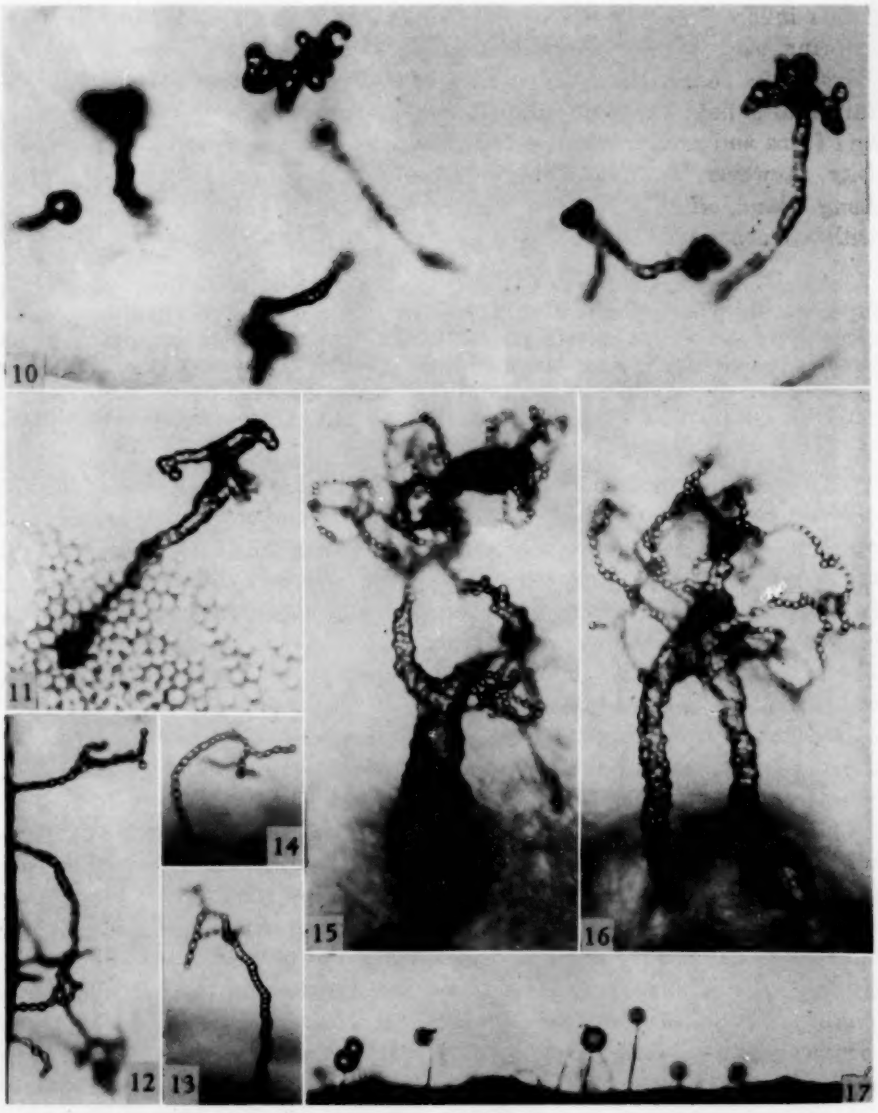
Acrasis **rosea** sp. nov.—Cellulae omnes cytoplasmate roseo impletae; myxamoebae pseudopodiis lobatis praeditae; microcystes plerumque sphaericales, 8–18 × 9.5–20 μ, interdum multo majores; pseudoplasmodia non migrantia; sorocarpi rosei, magnitudine et complicatione variabilissimi, e catena una sporarum e caule simplici usque ad catenas multas ramosas e caulibus simplicibus vel trunciformibus variantes; sporae typice sphaericales, 7.2–13.5 × 8.1–15.3 μ.

All cells with pinkish cytoplasm; myxamoebae with lobose pseudopodia; microcysts mostly spherical, 8–18 × 9.5–20 μ, sometimes much larger and up to 43 μ diam., some irregular ones up to 50 × 66 μ; pseudoplasmodia not migrating; sorocarps pink, very variable in size and complexity, ranging from a single short chain or branched chains of spores on a uniseriate stalk to many branching chains arising from a trunk-like stalk, those with trunk-like stalks measuring 27–100 × 234–780 μ; spores typically spherical, smooth-walled, 7.2–13.5 × 8.1 – 15.3 μ.

On cultures of *Flavobacterium, Rhodotorula mucilaginosa,* and *Phoma,* isolated from dead florets of *Phragmites communis* collected in Somerville, New Jersey, and Jones Beach, New York.[2]

When *Acrasis rosea* and the associated *Flavobacterium,* a bright yellowish orange species, were placed on the peptone (0.2%)-yeast extract (0.2%)-dextrose (0.5%) medium recommended by Raper (1937) for other cellular slime molds, growth was poorer and no fruiting occurred. Nor did conditions improve when the concentration of nutrients was cut in half. However, an excellent balance between the *Acrasis* and the bacterium was obtained on our medium for *Sordaria fimicola,* which consists of Difco cornmeal-dextrose agar to which 0.1% yeast extract is added. Good growth and fruiting occurred on this medium, which has a pH of approximately 6.0. When the pH was varied in one direction by the addition of 1 or 2 drops of KOH and in the other by the addition of lactic acid, the results were always unfavorable and fruiting failed to occur. Therefore, we have used only the cornmeal-dextrose-yeast extract medium of pH 6.0 in our further studies of this organism.

[2] We are grateful to Dr. W. J. Corpe for the identification of the bacterium, and to Dr. L. J. Wickerham for identifying the yeast.



FIGS. 10–17. Photomicrographs of *Acrasis rosea* and *Protostelium mycophaga*.—FIGS. 10–16. Sporogenesis in *Acrasis rosea*.—FIG. 10. Development of multilobed sorogens. × 160.—FIG. 11. Sorogen lobes arranging themselves into chains of cells. × 160.—FIGS. 12–14. Sorocarps with uniseriate stalks. Note that the simplest sorocarp in fig. 12 has about three stalk cells and a simple chain of four spores. × 115.—FIG. 15. Large sorocarp with trunk-like stalk and many branching spore chains. × 115.—FIG. 16. Compound sorocarp formed by apical convergence of two. × 115.—FIG. 17. Stalked spores of *Protostelium mycophaga*. × 290.

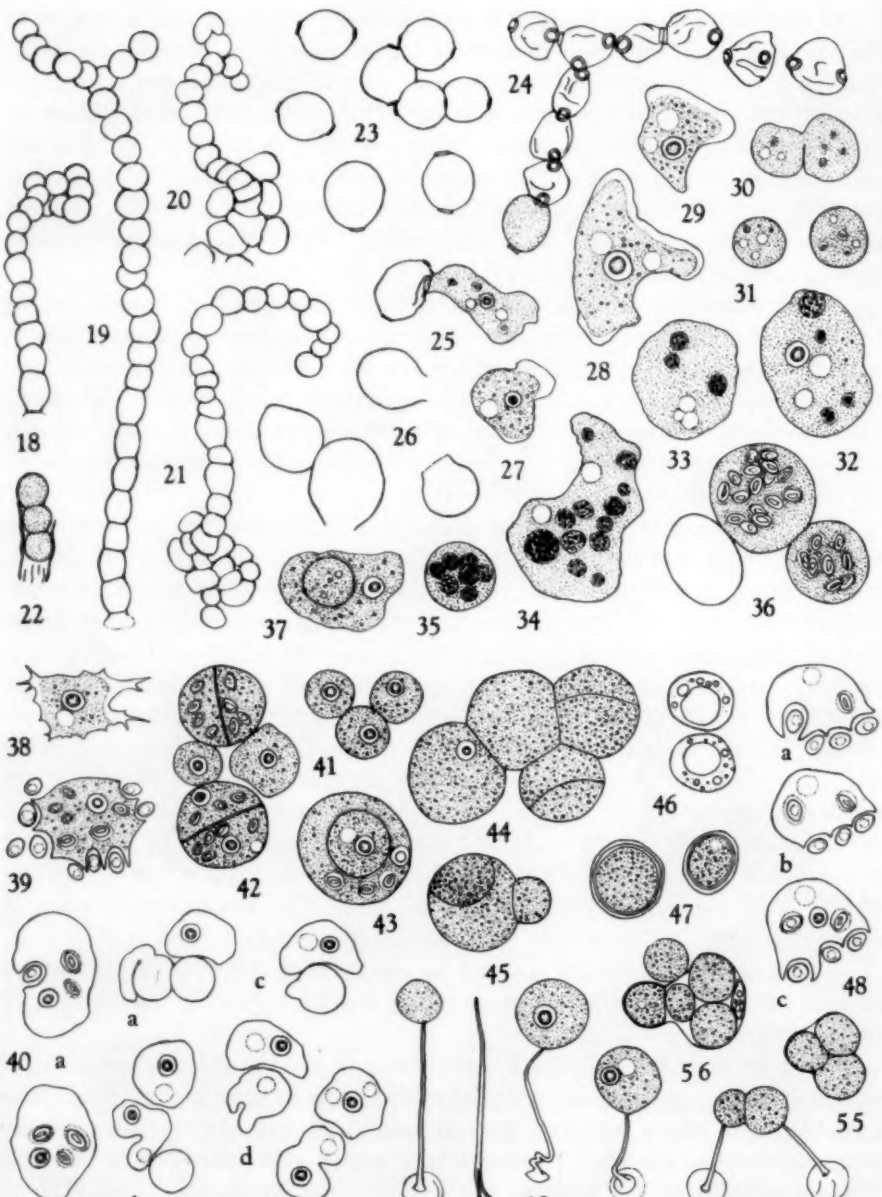
It was of particular interest to find that a pink yeast and a species of *Phoma* could function as food sources for *Acrasis rosea*. The myxamoebae readily ingest the cells of *Rhodotorula mucilaginosa* and the conidia of *Phoma*, the latter being pinkish in mass. Previously, only bacterial associates have been reported for most other cellular slime molds. A possible exception is *Acrasis granulata* discovered by van Tieghem (1880) on beer yeast. Since van Tieghem did not actually observe the ingestion of yeast cells by the myxamoebae, it is not certain that contaminating bacteria were not involved as food sources.

In his paper of 1880 is found van Tieghem's original description of the Acrasieae, in which he placed the 3 genera, *Guttulina*, *Dictyostelium*, and *Acrasis*, the latter being described for the first time. *A. granulata*, the type species, has been, until now, the only known member of the genus. It was never reported again after its original discovery. Since it has a number of features in common with *A. rosea*, a brief discussion of its characteristics is relevant at this point.

A. granulata was described as forming blackish growths on beer yeast, the color being due to a brown-violaceous pigment, not in the cytoplasm, but in the spore walls. In cultures in hanging drops of urine, the fructifications were described by van Tieghem as consisting typically of a single row of stalk cells with a crampon-like basal cell, often with other cells applied against it as buttresses, and a single chain of spores arising from the top of the stalk. There is no mention of branching among the spore chains. During sorocarp formation, amoeboid cells were reported to move along the stalk and become superimposed on one another to form a spore chain of variable length. The spherical spores measured 10–15 μ in diameter, and the stalk cells were 1.5–2 times as long as broad. On yeast paste, the sorocarps were inclined to be more complicated, usually having a compound stalk consisting of several (up to 10 or 12) closely united rows of cells, each row terminated by a single chain of spores.

The striking differences, as well as similarities, between *A. granulata* and *A. rosea* will be further emphasized in the following description of the new species.

When spores of *A. rosea* are transferred to a drop of water on an agar surface, some of them complete their germination in shortly over 1 hr. The amoeboid cell, which is faintly pinkish, makes its exit through an elongate pore dissolved in the wall, leaving a thin empty cyst behind (figs. 25, 26). The spore walls give a positive test for cellulose by turning pale blue in chloroiodide of zinc. As the myxamoebae crawl about, they reveal an area of nongranular ectoplasm, devoid of pigment, which is particularly prominent on the side that is migrating forward (figs. 27–29). As a number of figures show, each myxamoeba is provided with a single nucleus,



FIGS. 18–56. Camera lucida drawings of *Acrasis rosea* and *Protostelium mycophaga*. —FIGS. 18–36. *Acrasis rosea*.—FIGS. 18–21. Sorocarps with uniseriate stalks produced in hanging drop cultures.—FIG. 22. Base of broken stalk showing sheath.—FIG. 23. Spores, with ring-like thickenings at points of juncture.—FIG. 24. Chain of

in which a central body, presumably the nucleolus, is located, and one or two contractile vacuoles are present. Frequently, after a vacuole contracts it reappears as several smaller vacuoles (fig. 33), which quickly coalesce into a single larger one. On cultures of *Flavobacterium*, the myxamoebae ingest large numbers of bacterial cells, which tend to accumulate in conspicuous masses within food vacuoles (figs. 32–35). Later, balls of bacterial remains are expelled from the temporary posterior end of the cell. The larger mass in the cell illustrated in fig. 32 was discharged just after the drawing was made. In hanging drop cultures, numerous discharged balls of bacterial remains may be observed after several days of growth. Many of the amoebae become quite gorged upon the bacteria and much larger than when they came out of the spores, as the figures show. On cultures of *Rhodotorula* or *Phoma*, the myxamoebae often ingest large numbers of yeast cells or conidia, respectively, and become quite large. Cannibalism, reported by several investigators in other members of the Acrasiales, is not uncommon in *A. rosea* (fig. 37).

The myxamoebae multiply by simple division (figs. 30, 31). The behavior of the myxamoebae may be readily observed in hanging drop cultures (fig. 1). If conditions are favorable, fruiting may also occur in these

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mostly empty spores found dried on surface of cover slip. Note the distinct ring-like thickenings.—FIG. 25. Germinating spore. The amoeba reversed itself and returned into the cyst before making a final exit.—FIG. 26. Empty spore cysts.—FIGS. 27–29. Myxamoebae. Note nucleus and one or two contractile vacuoles.—FIG. 30. Dividing myxamoeba.—FIG. 31. Daughter cells of same division in process of encysting.—FIGS. 32–34. Large myxamoebae with balls of *Flavobacterium* cells in food vacuoles.—FIG. 35. Microcyst with balls of the same bacterium.—FIG. 36. Microcysts from colony of *Rhodotorula*. Note empty cyst and yeast cells in the other two.—FIG. 37. Cannibalistic myxamoeba with ingested microcyst.—FIGS. 38–56. *Protostelium mycoghaga*.—FIG. 38. Myxamoeba with filose pseudopodia. Note nucleus and contractile vacuole. FIG. 39. Myxamoeba with pseudopodia extended between *Rhodotorula* cells. Note ingested yeast cells.—FIG. 40. Myxamoeba during (a) and after (b) ingestion of yeast cell.—FIG. 41. Microcysts.—FIG. 42. Microcysts of various sizes from *Rhodotorula* cultures. Two of the cysts contain two cells each. Note the ingested yeast cells.—FIG. 43. Large microcyst with ingested yeast cells and smaller microcyst.—FIG. 44. Closely appressed group of large microcysts, two with two cells each.—FIG. 45. Large microcyst with two, probably non-daughter, cells and a small adhering microcyst.—FIG. 46. Deteriorating microcysts with pigmented globules.—FIG. 47. Microcysts that have re-encysted within the original thin walls.—FIG. 48. Stages in ingestion of *Rhodotorula* cells by a myxamoeba. In (a) and (b) a yeast cell is ingested. In (c) the pseudopodia were withdrawn from around the yeast cells.—FIG. 49, a–e. Stages in the reversion of three spores to the amoeboid form, with no empty cysts remaining.—FIG. 50. Single stalked spore. Note thin empty cyst at base.—FIG. 51. Stalk with lumen extending for a short distance into the basal part.—FIGS. 52, 53. Single, stalked spores. Note uninucleate condition of spores and basal flare of stalk.—FIG. 54. Two stalked spores that have accidentally grown together apically during sporongenesis. Note the thin empty cysts at base. —FIG. 55. Three spores within a common sheath, formed when three stalked spores came together apically during sporogenesis.—FIG. 56. Five spores, one degenerate, within a common sheath. A sixth spore adheres to the group externally. All figures × 690, except figs. 18–22, × 350.

cultures. Prior to this, there is a decided tendency of the myxamoebae to aggregate in clusters, but without any converging streams of migrating cells being apparent. If conditions become unfavorable for fruiting the aggregated cells simply encyst (fig. 3). In all cultures that are several days old, numerous encysted cells, known as microcysts, are found. These frequently contain ingested cells of the associated organism (figs. 35, 36). Many myxamoebae migrate for considerable distances beyond the margin of the colony and, upon failing to reach suitable food, encyst singly or in groups on the agar surface (figs. 2, 4). If proper conditions are restored, the microcysts may germinate and produce myxamoebae, leaving a thin cellulose wall behind. Although most microcysts are spherical, or nearly so, and measure 8–18 × 9.5–20 μ, those developing from large, gorged myxamoebae are much larger. On cultures of *Phoma*, some spherical ones were found that had reached a diameter of 43 μ, while occasional irregular ones ranged up to 50 × 66 μ.

On colonies of *Rhodotorula* in particular, very large numbers of myxamoebae and cysts develop in a relatively short period. The cell masses appear bright rose to nearly blood red in the densest areas. If mass transfers are made from such colonies to fresh agar plates, fruiting will generally begin within 3, sometimes 2, days. New sorocarps may continue to develop over a period of several days. Simple sorocarps with uniseriate stalks (figs. 12–14, 18–21) to more complex ones with trunk-like stalks (figs. 15, 16) develop on all 3 of the previously mentioned nutritive associates, but the most robust ones appear on *Rhodotorula*. On the latter, the greatest areas of sorocarp formation are around the peripheries of the colonies. The myxamoebae migrate to the edge of the colony in large numbers, frequently forming a broad and continuous band of cells. Or small to large clusters of cells may appear at or beyond the periphery of the colony, sometimes completely losing contact with the yeast cells. It is chiefly in these peripheral masses of myxamoebae that the pink pseudoplasmodia appear (fig. 6.). In cultures of *Phoma*, the pseudoplasmodia arise from the agar surface where the conidia were discharged and from the walls of the pycnidia (fig. 5).

The pseudoplasmodia, consisting of globose to oblong masses of amoeboid cells, arise singly or in groups, depending largely upon the size of the aggregation of myxamoebae. They do not migrate. Stages in the development of the pseudoplasmodia and sorocarps were overlooked until it was finally discovered that they were appearing at a specific time of day. When vigorously growing cultures 3–5 days old were examined between 8 and 9 A.M., pseudoplasmodia were readily found. A number of these were followed throughout their development into mature sorocarps. This is a surprisingly rapid process. Fully developed pseudoplasmodia may give rise to mature sorocarps within 1–2 hrs.

Sorocarp formation is in some ways like that described in certain other cellular slime molds, while in other ways it is unique. First, the pseudoplasmodium becomes differentiated into a globose sorogen of amoeboid cells that arises on a stalk-like base (figs. 5, 6). The sorogen is able to continue its upward movement by virtue of the fact that it is continually adding cells to the stalk as it proceeds. The stalk cells rapidly encyst, and further support is given to the stalk by a sheath which surrounds the stalk cells (fig. 22), regardless of whether the stalk is uniseriate or trunk-like. These cells show considerable variation in size, and in uniseriate stalks they are frequently somewhat longer than broad and are flattened at each end. The trunk-like stalks may be many cells in thickness. Their cells often show several flattened sides where they come into contact, but there are many spaces between them and they are not closely compacted into the polygonal patterns characteristic of *Dictyostelium*. Neither are they sacrificed to the sole function of stalk formation as they are in *Dictyostelium*, for they remain filled with normal cytoplasm and, if transferred to fresh agar, will germinate like microcysts and spores.

The uniseriate stalks do not appear to have a distinct crampon-like cell at the base, as described by van Tieghem for *A. granulata*, nor is there any good evidence of buttressing cells. Frequently, encysted cells are present around the base (figs. 20, 21), but the sorocarp may stand alone with no such cells apparent (figs. 18, 19).

Sporogenesis is an interesting and unusual process. When the stalk is finished and the sorogen ceases its upward migration (fig. 7), the globose to oblong sorogen typically becomes lobed (figs. 8, 9). Each lobe may become further lobed (fig. 10). The lobes contain amoeboid cells in motion. These cells now move about relatively rapidly in such a way as to arrange themselves into chains (fig. 11). There are several variations in the method of chain development. The myxamoebae in some lobes move about in such a way as to arrange themselves almost simultaneously into a single series. As soon as the catenulate arrangement occurs, the cells quickly round up and encyst. Any excluded myxamoebae may, if alone, encyst individually along the side of a chain, or, if there are several in a group, these may arrange themselves into a short side chain (figs. 19, 20). A myxamoeba very near the end of a chain may migrate to the tip of the terminal spore (fig. 20) and encyst, but there is only restricted migration of individual myxamoebae during spore formation.

Often, after the myxamoebae in a lobe of the sorogen have arranged themselves into a chain, the chain may further elongate, not through the migration of more cells out to the tip, but by the interstitial insertion of more myxamoebae in catenulate order from the proximal, still amoeboid mass of the sorogen or sorogen lobe. Thus, the older, terminal cells of the

chain are pushed out as new ones are added from the proximal amoeboid masses. Spore formation is a rapid process. A sorogen lobe may develop into a chain of encysted spores within 20 to 30 min. Occasionally, some of the simpler sorocarps fail to develop chains and the amoebae of the sorogen encyst in a cluster at the apex of the stalk (fig. 18).

The simplest sorocarps may have only 2 or 3 stalk cells and a simple chain of 4 or 5 spores (fig. 12), while the largest have hundreds of cells in their trunk-like stalks, several main branches above, and an elaborate system of branching spore chains (fig. 15). Occasionally, 2 sorocarps may accidentally come together apically during their development, the sorogens coalescing and producing a common system of spore chains (fig. 16). Some sorocarps have stalks that are several cells in thickness above but taper down to a single series of cells at the base; a few that have stalks several cells in width taper above to produce a single filament of spores. The spore chains as well as the stalks are somewhat hygroscopic. Often, during observation, the chains or stalks slowly curve about, and a number of sorocarps fall back onto the surface of the medium.

The spores, which tend to be more or less spherical, are more constant in size and shape than are the stalk cells (fig. 23). They may be readily distinguished from the stalk cells by a ring-like thickening, or hilum, at the point of juncture with an adjacent spore. Most spores, therefore, have a hilum at each end, while a spore from which a side branch arises has 3 of these structures, and a terminal spore has but 1 (fig. 23, 24).

No evidence of a sexual stage in the life cycle was observed, but the method of study would certainly not eliminate the possibility of its occurrence. Single-spore cultures develop normally and give rise to typical sorocarps. Such cultures require a vegetative period of 6 or more days before fruiting will occur.

Since *A. rosea* had already shown considerable versatility in its food sources, more attention was given to this subject. The organism was tested on several different bacteria, as well as a number of yeasts and yeast-like forms. Inocula free of the organism on which the *Acrasis* is growing may be obtained by carefully removing some of the spores without touching the surface of the colony, or by cutting out sections of agar onto which the myxamoebae have migrated from the colony. Contamination is most easily avoided by making transfers from cultures of *Rhodotorula*.

One of the most satisfactory bacterial associates for the culture of a number of cellular slime molds is *Escherichia coli*. However, this bacterium fails to support the growth of *Acrasis rosea*. Since *A. rosea* has been isolated from nature only on pigmented organisms, it was decided to test other pigmented forms. The pigmented bacteria tested were *Serratia marcescens*, *Chromobacterium violaceum*, *C. chocolatum*, *Pseudomonas aeruginosa*, *P.*

fluorescens, Bacillus megaterium (a light orange variant), *Staphylococcus aureus, Mycobacterium smegmatis,* and *Nocardia* sp.[3] On none of these did growth of the *Acrasis* occur. In the presence of some of these bacteria, the myxamoebae appeared to be inhibited or killed even without coming into direct contact with the bacterial cells.

The yeasts and yeast-like forms tested were *Hansenula anomala, Saccharomyces cereviseae, Schizosaccharomyces pombe, Ustilago violacea, Sporobolomyces* sp., and *Sporidiobolus* sp. The first 4 organisms failed to support the development of *Acrasis rosea.* However, whenever *Flavobacterium* was present as a contaminant, the myxamoebae were able to multiply and ingest the budding cells of all these fungi. It would appear, therefore, that the latter are in no way antagonistic to the myxamoebae, but that they simply lack one or more required substances present in the bacterium. It is quite possible that these substances are carotenoids.

On pure cultures of *Sporobolomyces* and *Sporidiobolus,* which are classified among the basidiomycetes, the myxamoebae multiply and ingest the yeast-like cells readily, but on *Sporobolomyces* sorocarp formation is poor and delayed, and on *Sporidiobolus* it fails to occur altogether. *Sporidiobolus* forms yeast-like cultures that are at first whitish, but after several days show a faint pinkish tint. Growth is good on these cultures but less vigorous than on the bright pink yeast-like colonies of *Sporobolomyces.* The increase of myxamoebae and the ingestion of host cells are so rapid on streak cultures of the latter that they soon appear as though lysed, no cells of *Sporobolomyces* being left in these areas. This excellent vegetative growth does not coincide with good fruiting, for sorocarps are produced only sparingly.

During these studies, an albino mutant of the pink *Rhodotorula* appeared and was isolated. It forms white colonies with none of the characteristic pigmentation of the wild type, although after 10 days there is a very faint pinkish tinge to the colonies. When *Acrasis* spores and cells of the albino yeast were transferred together to several spots on an agar plate, there was good growth of both organisms. After 9 days, a considerably longer period than required with the wild pink yeast, numerous bright pink or pinkish orange pseudoplasmodia were appearing, and the cultures had become bright rose from the presence of large numbers of *Acrasis* cells. The pseudoplasmodia developed into normal, pink sorocarps. However, the average sorocarp was somewhat less robust than on the wild type yeast, and fruiting was probably not as abundant.

Only a few preliminary experiments have been carried out on the effects of light and temperature upon growth and fruiting. Cultures of *Acrasis rosea* on wild type *Rhodotorula* placed in the dark failed to fruit over a 9-day period, whereas controls left out in the laboratory were fruiting

[3] Cultures supplied by Dr. W. J. Corpe of Barnard College.

abundantly within a few days. The myxamoebae multiply rapidly in the dark but eventually encyst in large numbers without reaching the pseudoplasmodial stage. Such cultures do not fruit when brought back into the light. Cultures placed in a box with light directed through a small slit on one side showed normal fruiting, but there was no noticeable orientation of migrating myxamoebae or of sorocarps towards the light source.

Cultures on *Flavobacterium*, stored under various conditions, were tested for survival after approximately one month. The *Acrasis* had failed to survive in 2 plate cultures containing spores and microcysts kept in a 23° C incubator and in a test tube culture without spores which was left out in the laboratory. However, the organism was recovered from a culture which, after sporulation, was kept in a cold room at about 8° C. A culture on *Flavobacterium* containing large numbers of myxamoebae was placed in a 30° C incubator for 5 days, by which time it was difficult to find any evidence of the *Acrasis*. Only with some effort was it possible to recover the organism by making fresh transfers from the plate.

The second organism, which is a much simpler one, is described in the following section.

Protostelium gen. nov.—Myxamoebae pseudopodiis filosis praeditae; microcystes sphaericales praesentes; pseudoplasmodia carentia; sorocarpus typice e spora una ad apicem caulis filiformis, non-cellularis nata; capita composita e conjunctione sporarum duarum vel plurium per sporogenesem efformata.

Myxamoebae with filose pseudopodia; spherical microcysts present; pseudoplasmodia lacking; spores typically borne singly at the apices of filiform, non-cellular stalks, occasionally several on a single stalk; compound heads also developing by coalescence of two to several spores during sporogenesis. (The generic description is expanded to include a new isolate of *Protostelium*, which will be described in a later publication.)

Type species: *P. mycophaga*.

Protostelium **mycophaga** sp. nov.—Cellulae omnes e pigmento aurantio in cytoplasmate impletae; microcystes 9–27 × 9–30.5 μ; caules sporiferi e vix evoluti usque ad 70 μ longi variantes, disco prolatione basilari ornati, super discum prolationem circa 1 μ crassi, ad apicem usque circa 0.5 μ attenuati; sporae typice globosae, 4.1–11.6 μ.

All cells with orange pigment in the cytoplasm; amoebae with single nucleus and usually 1 contractile vacuole; microcysts typically spherical, 9–27 × 9–30.5 μ; spore stalks ranging from barely developed up to 70 μ in length, with basal flare, thickness above flare about 1 μ, diminishing to about 0.5 μ at apex; spores typically globose or sub-globose, produced singly or in groups of 2–6, measuring 4.1–11.6 μ diam.

Isolated from cultures of *Rhodotorula mucilaginosa* and *Phoma* ob-

tained by plating out suspensions of dead florets of *Phragmites communis* collected in Somerville, New Jersey.

Protostelium mycophaga was isolated from the same 2 Somerville collections in which *Acrasis rosea* was discovered. In several areas on the plates the two organisms occurred mixed in the same colonies of *Rhodotorula*. In the present study only the previously described cornmeal-dextrose-yeast extract medium (pH 6.0) was used.

The myxamoebae, which are uninucleate and generally provided with a single contractile vacuole, differ strikingly from those of *Acrasis rosea* in having finely pointed and often branched pseudopodia (figs. 38, 39, 48). The cytoplasm contains an orange pigment which seems to be located in fine granules or droplets, whereas the hyaline ectoplasm is devoid of the pigment (fig. 38). A number of degenerating microcysts from a 12-day-old culture were found to contain several oily looking droplets of varying sizes in which the orange pigment was located (fig. 46). Observations of hanging drop cultures of *Protostelium* on *Rhodotorula* reveal that the myxamoebae ingest the yeast cells by enveloping them with their pointed pseudopodia (fig. 48), although on occasion these pseudopodia may appear less filose (fig. 40). In cultures crowded with yeast cells, a myxamoeba may have quite a number of pointed pseudopodia extended between the yeast cells (fig. 39). In most cases the yeast cells are not ingested and the pseudopodia are withdrawn.

In young cultures of *P. mycophaga* on *Rhodotorula*, the myxamoebae remain confined to the yeast colony. Later, as the colony becomes crowded with myxamoebae, many of these crawl out onto the agar, where they eventually encyst or sporulate. Some migrate for considerable distances. If they come into contact with fresh yeast colonies they enter and multiply. Myxamoebae around the edge of a crowded colony of *Rhodotorula* often show a peculiar behavior. The cell first sends out a neck-like extension with a refractile granule at the tip, while the main body of the cell remains within the margin of the colony. The myxamoeba may then deposit the granule as though it were a waste product and withdraw the neck-like extension, or it may retain the granule and move completely out of the yeast colony. Many small deposited granules may be observed around a crowded colony.

As the myxamoebae wander about on the agar surface, they leave faint tracks. These tracks are irregular and sinuous and frequently cross back over themselves. Their possible significance will be mentioned in the discussion.

After several days of development, many encysted cells occur within and outside the yeast colony (figs. 41–45). Since the myxamoebae are variable in size, some of them becoming quite large and gorged with yeast cells,

they develop into microcysts that are correspondingly variable in size, some of which still contain ingested cells (fig. 42). Since myxamoebae are sometimes cannibalistic, smaller cysts may also appear in them or in the microcysts (fig. 43). Some of the larger microcysts are 2-celled (figs. 42, 44, 45) and upon germination give rise to 2 myxamoebae instead of the usual 1. It is not certain whether this is the result of cell division just after encystment, or whether 2 adjacent myxamoebae or 2 recently produced daughter cells have rounded up within the same cyst wall. The occurrence of some cysts with 2 cells of different size and cytoplasmic density (fig. 45) indicates that this type, at least, may have developed from 2 adjacent amoebae that were not daughter cells. As figs. 44 and 45 show, microcysts may adhere to each other.

The microcysts generally have thin walls that do not give a clear-cut test for cellulose in chloroiodide of zinc. However, in a culture 2 weeks old, a number of microcysts were found in which the protoplast had re-encysted and secreted a thicker wall, the original wall then appearing as a thin, loose outer case (fig. 47). When these cells were tested for cellulose, the inner wall gave a distinctly positive reaction. When recently developed microcysts are placed on fresh agar, some of them simply revert back to the amoeboid form without leaving any evidence of a cyst wall, whereas others leave behind a very thin collapsing wall. Germination of the latter type begins by a softening of the cyst wall on one side, after which the myxamoeba moves out of its thin collapsing shell. When microcysts were placed in a plasmolyzing salt solution, they all appeared to have thin cell walls. It is possible, therefore, that those microcysts which appeared to revert back directly to the amoeboid form did so by resorption of the cell wall.

After cultures of *Protostelium mycophaga* have developed for several days and have become crowded with myxamoebae, many of which are migrating out of the host colony, sporulation occurs abundantly at and well beyond the periphery of the colony (figs. 17, 50–56). Several myxamoebae were observed in the process of spore formation. At first, the amoeba seems to round up, but in side view it appears as a hemispherical mound. The cell then begins to rise on a very narrow stalk formed by the amoeboid cell as it rises. Stalk formation was completed by one such cell in about 7 min., by another in 16 min., the stalks being 23 μ and 25 μ in length, respectively. It is probable that the first step in sporulation, as represented by the hemispherical amoeba, is a brief encystment stage, in view of the fact that what appears to be a very thin, collapsed cyst wall may frequently be seen at the base of the stalk (figs. 50, 53, 54). The base flares out somewhat, undoubtedly giving support to the stalk. The base is often somewhat like a minute inverted cup or funnel. Most stalks are solid above the basal flare, but some show an attenuated lumen extending upwards into the stalk for a short distance (fig. 51).

Very often the stalked spores are produced in congested numbers. Under these circumstances 2 or more spores frequently come together into a common head during sporogenesis. This apparently accidental convergence involves only the amoebae and not the stalks (fig. 54). From 2 to 6 spores may thus be brought together within a single group surrounded by a common sheath (figs. 55–56). There are as many separate stalks as spores present. As fig. 56 shows, a spore may adhere without being included within the sheath. This is probably because the spore became applied tardily, after the other spores had encysted. The spores are sticky and can be picked off with a micromanipulator needle in a catenulate series as they adhere to one another. This stickiness might facilitate their being picked up and transported by small insects in nature. Many stalks devoid of spores may be seen on the agar surface. We have not observed how this comes about, but suspect that the spores under proper conditions may germinate or revert to the amoeboid state in situ and crawl back down the stalk onto the agar.

The spores are most often globose, or nearly so, although some vary to broadly oblong. When placed in a plasmolyzing salt solution, at least some of them can be seen to have a thin cell wall. This wall does not give a satisfactory reaction for cellulose in chloroiodide of zinc. Some of the stalked cells are found to be quite soft when probed with the needle of a micromanipulator. When spores are transferred to fresh agar, they may, like the microcysts, revert to the amoeboid form without leaving a trace of a cell wall (fig. 49), or they may leave behind a thin empty cyst. Probably this inconsistency as to the presence or absence of a cell wall is related to the degree of maturation of the stalked cells.

Although the method of study here would not negate the occurrence of a sexual phase in the life cycle of *Protostelium mycophaga,* we have observed no stages that could be interpreted as sexual. Also, cultures started from single cells develop as normally as those started with a mass of cells.

As previously noted, *P. mycophaga* was isolated from nature, not only on *Rhodotorula,* but also on a species of *Phoma.* It grows well on the latter and readily ingests the discharged conidia. Other host organisms tested were *Saccharomyces cereviseae, Hansenula anomala, Schizosaccharomyces pombe,* an albino mutant of *Rhodotorula, Ustilago violacea, Sporobolomyces* sp., and *Sporidiobolus* sp. There was no survival on the first 2 organisms, while very slow multiplication of myxamoebae, followed by their eventual death, occurred on *S. pombe.* Even so, the cells that were present were orange-pigmented. On all the other fungi, *P. mycophaga* developed rapidly, the cells having the characteristic orange color in mass, and abundant sporulation occurred. The organism does not grow on any of the chromogenic bacteria mentioned earlier in this paper.

Little is known as yet about the longevity of the organism and its

temperature tolerance. A culture kept in the cold room for 1 month at 8° C failed to survive, while a culture left out in the laboratory for the same length of time gave viable transfers. When cultures on *Rhodotorula* were placed in continual darkness for 5 days and then examined, it was found that there had been a great increase in the number of myxamoebae, which were normally pigmented, and that abundant sporulation had occurred. The proportion of microcysts was less than in cultures left out in the laboratory, but large numbers of microcysts developed several days later in cultures returned to the dark, at which time the number of microcysts and spores exceeded that found in cultures left out in the laboratory. Also migration of myxamoebae had occurred over a greater area in cultures kept in the dark. When fresh cultures were placed in a box with light directed only through a small slit on one side, there was no orientation in the direction of migration of myxamoebae with respect to the light source, nor did the spore stalks respond in any consistent manner to the light source.

Discussion.—The various differences between *Acrasis rosea* and *A. granulata* have already been brought out, the most important of these being with respect to the nature of the pigmentation, the mode of development of the larger sorocarps, the character of the spore walls and of the spore chains—whether branched or unbranched.

The possible phylogenetic position of the genus is of particular interest. E. W. Olive (1902) placed it in the Dictyosteliaceae, a family that is characterized by having myxamoebae with filose pseudopodia and sorocarps in whose stalks the cells are compacted together in polyhedral patterns. The Guttulinaceae, according to this author, have myxamoebae that are "either limax shaped, without pseudopodia, or of the ordinary form, with rounded or lobose short pseudopodia," and the stalk cells are less highly modified. We believe that the type of myxamoeba, as evidenced by the filose or lobose character of the pseudopodia, may be of much greater importance than has been generally recognized. Recently, Raper and Quinlan (1958), in their discussion of the Dictyosteliaceae, have given some emphasis to this feature. It should be noted that the myxamoebae of *Acrasis granulata* were not described by van Tieghem in sufficient detail to permit their classification as to type of pseudopodia. As previously noted, however, *A. rosea* has lobose pseudopodia.

As already noted, the trunk-like stalks of *A. rosea* contain numerous encysted cells rather loosely jumbled together, and only here and there with flattened sides where they are pressed together. They remain filled with cytoplasm and retain their ability to germinate. On the contrary, the cells in the multicellular stalks of the Dictyosteliaceae become closely appressed into polygonal shapes, lose most of their cytoplasm and their germinability, and are thereby wholly sacrificed to the specialized function of

stalk formation. It is therefore suggested that the proper position for *Acrasis,* as indicated by our studies of *A. rosea,* is in the Guttulinaceae rather than the Dictyosteliaceae.

In the Guttulinaceae, *Acrasis* would probably occupy the most advanced position. *Guttulina,* with its mostly sessile or short-stalked sorocarps, and *Guttulinopsis,* with its more elongated stalks, are less highly modified and probably more primitive. Both produce globular or oblong to irregular masses of spores. The failure of chain formation and the resultant encystment of spores in a cluster at the tip of the stalk in some of the smaller sorocarps of *Acrasis rosea* may be a further indication of relationship to the other two genera. If the process of sorocarp formation were consistently arrested in a stage like that shown in fig. 7, followed by encystment of the cells in the sorogen, a condition similar to that in *Guttulinopsis stipitata* would be obtained. Recently, Dr. K. B. Raper and his group (personal communication) have discovered a new member of the Guttulinaceae isolated from eagle dung, which produces lobed fruiting bodies, some of which are remarkably like the lobed sorogen stages of *Acrasis rosea* (figs. 8–10). These observations indicate that, of the forms now known, *Acrasis* is the culmination of the phylogenetic series comprising the Guttulinaceae.

As for *Protostelium mycophaga,* one might at first consider it barely worthwhile to attempt to separate it from the Protozoa, particularly in view of the fact that it fails to form distinct pseudoplasmodia and that it produces its spores so simply. Dr. Raper (personal communication) states that some time ago he obtained among his isolates a form resembling ours, and that he has been unable to find any reference to a previously described organism of this type, either in the Protozoa or the Acrasiales. This has been our experience also. We believe that there are several important reasons for considering *Protostelium* a member of the Acrasiales. These include the distinct test for cellulose given by the thick-walled microcysts, the mode of development of the stalked spores, and the nature of the spore stalks.

Recently, Raper and Quinlan (1958) described a new genus and species, *Acytostelium leptosomum,* for which they proposed the new family name, Acytosteliaceae because of a non-cellular stalk. As is characteristic of the Dictyosteliaceae, the myxamoebae have filose pseudopodia. Pseudoplasmodia are present. An anteriorly situated group of myxamoebae in the sorogen produces a slender, non-cellular stalk with a narrow lumen as the sorogen moves upward on the developing stalk. If one were to postulate the simplest modification of this process, it would probably be similar to what occurs in *Protostelium,* where a single amoeba arises on a very narrow, non-cellular stalk and encysts to form a single spore at the tip. Another striking resemblance is found in the extension of a lumen into the basal portion of some stalks of *P. mycophaga.* Also of considerable importance is the fact

that the myxamoebae have filose pseudopodia. The fact that the migrating myxamoebae leave behind them distinct slime trails may also be of some significance in indicating a relationship to this group. Slime trails left by individual migrating myxamoebae of *Dictyostelium discoideum* were reported earlier by Paddock (1953). Their exact nature is not understood.

The genus *Sappinia* of the Sappiniaceae, a family of doubtful position in the Acrasiales, is described as having no true pseudoplasmodia and producing pedicellate cysts in addition to unstalked clusters of spores (possibly microcysts) at the ends of projections from the substratum. However, any attempt to make a serious comparison of *Sappinia* with *Protostelium* is met with difficulty. The amoebae of *Sappinia* have lobose pseudopodia, and the stalk of the cyst, according to the description of Dangeard (1896), is merely a narrow extension of the cell. This is evidenced by the fact that the extension, or pedicel, at first contains cytoplasm. Furthermore, the amoebae are binucleate, and, as Wenrich (1954) has shown, there is a distinct sexual phase in the life cycle. We are in agreement with Wenrich that the genus should be excluded from the Acrasiales. The latter author places *Sappinia* in the order Amoebina of the Protozoa.

Bonner (1959) has suggested that *Acytostelium* is a less advanced member of the Dictyosteliaceae and may have given rise to the *Dictyostelium-Polysphondylium* line. He further suggests that the ancestral form of *Acytostelium* may have resembled *Sappinia* in some ways, although he does not consider that genus the actual precursor. *Protostelium* would in many ways seem to fill the position of a hypothetical ancestor. Bonner favors the theory of a single main phylogenetic line in the Acrasiales, the Guttulinaceae being a degenerative branch originating from a *Dictyostelium*-like ancestor. For reasons already presented, we believe that the Guttulinaceae are a separate line that diverged much earlier or possibly arose independently. In our present state of knowledge of the cellular slime molds, it is difficult to deduce whether there has been a single main line of development among the remaining cellular slime molds, as Bonner suggests, or whether there have been two main lines that diverged early from a primitive form. One line, characterized by acellular stalks, may have led from a *Protostelium*-like ancestor to *Acytostelium*, and the other, characterized by multicellular stalks, may have led from the same ancestor to *Dictyostelium* and *Polysphondylium*. Discoveries of new cellular slime molds should do much to fill in the gaps in our knowledge of this subject. We tentatively place *Protostelium* in the Acytosteliaceae.

It is noteworthy that both of our new species are brightly pigmented. E. W. Olive (1902) has pointed out that of all the species known at that time, only *Guttulina rosea* possessed a pigmented protoplasm, the color of all the other pigmented species being confined to the cellulose walls. Raper

(1937, 1940) found that when *Dictyostelium discoideum* was grown on *Serratia marcescens*, the myxamoebae and sorocarps were reddish, apparently because of the failure of the cells to digest the red pigment prodigiosin. When the organism was grown on *Sarcina lutea*, the sorocarps were yellow. On the other hand, when *D. mucoroides* was grown on *Serratia marcescens* it remained unpigmented, apparently as a result of the digestion of prodigiosin by the myxamoebae.

In a review article on fungal carotenoids, Goodwin (1952) notes that several carotenoids are present in *Rhodotorula* and that 2 have been identified in *Sporobolomyces*. It is believed that *Saccharomyces cereviseae* does not normally produce carotenoids. We have already shown that *Acrasis rosea* and *Protostelium mycophaga* develop well on the first 2 organisms, but fail to develop on the *Saccharomyces*. It has also been noted that both species grow well on an albino mutant of *Rhodotorula mucilaginosa*, and on the nearly white cultures of *Sporidiobolus*, and that on these the myxamoebae are normally pigmented. Both of these nutritive associates assume a very faint pinkish tinge with age, and it is therefore possible that either carotenoids or their precursors are present in sufficient quantity to meet the requirements of normal vegetative development in both cellular slime molds. Since the pigments are consistently present and in apparently unaltered concentration in the myxamoebae, regardless of the degree of pigmentation of the associated microorganism, it is likely that they have a definite function in the cell. Perhaps this function is of a respiratory nature, as has been suggested previously by Champeau and Luteraan (1946). In *Acrasis rosea* they may also have some phototropic function connected with the development of pseudoplasmodia and sorocarps at a specific period of the day.

SUMMARY

Two new cellular slime molds are described from New Jersey. *Acrasis rosea*, a new species with a pink pigment in all its cells, produces fruiting bodies with branching chains of spores. It has been isolated on an orange bacterium and several pigmented fungi. *Acrasis* probably occupies an advanced position in the Guttulinaceae. The second organism, *Protostelium mycophaga*, is described as a new genus and species. Its cells also contain a pink pigment. It grows well on *Rhodotorula* and several other fungi, especially pigmented ones. During sporulation a single amoeba arises on a slender stalk and encysts at its apex. The genus is tentatively considered a primitive member of the Acytosteliaceae.

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GILBERTELLA GEN. NOV. (MUCORALES)

C. W. HESSELTINE

One of the curious species placed in the genus *Choanephora* is *C. persicaria* Eddy. Eddy (1925) described this species, which was isolated by Dr. Mix in 1918 from decaying peaches found on the New York market. Peaches were inoculated with this isolate by inserting fragments of mycelium into the fruit. Within seven days all infected peaches were entirely decayed and the fungus had fruited abundantly over the surface of the peaches. Unlike *Rhizopus* rot, the decayed tissue of the peaches remained fairly firm without collapse or "leak" of the fruit.

In a recent treatment of the Choanephoraceae (Hesseltine, 1953) *C. persicaria* was recognized as a valid species even though no one had reported it since its original isolation. Some workers, such as Zycha (1935), have simply reduced it to synonymy under *Blakeslea trispora* Thaxter or considered it as a doubtful species (Dantas, 1953). This curious species has interested the author ever since reading Eddy's short but good description of *C. persicaria* and the purpose of this paper is to report its rediscovery, to describe the species more fully, and to discuss its relationships.

In his paper Eddy referred to Thaxter's account of an unusual species which may have been the same as *C. persicaria.* This reference (Thaxter, 1914) stated that Thaxter had seen a form isolated by Blakeslee which produced appendiculate spores as in *Choanephora* but never formed any conidia. It is possible that Thaxter's form is Eddy's species or it may have been *C. circinans* (Naganishi and Kawakami) Hesseltine and Benjamin. Another possible reference to *C. persicaria* is found in Christenberry (1940), who described a *Mucor* sp. No. 2 that had gray to black colonies which were only 5 mm. high. He had isolated this species from soil near Fayetteville, North Carolina. Especially interesting is the fact that its sporangia broke open and in one figure he shows a mature sporangium borne on a bent sporangiophore. Gemmae are also stated to be present. These are all characteristics found in *C. persicaria.* However, no mention is made of appendaged sporangiospores so one is still in doubt whether it is identical with Eddy's organism.

Dr. I. M. Lamb, Curator, Farlow Herbarium, was kind enough to lend me two herbarium specimens of *Choanephora.* One specimen marked "*Choanephora persicaria* Eddy, Harvard Cult. Coll. Eddy Type Cult." proved to be *Absidia,* probably *A. cylindrospora* Hagem, since cylindrical sporangiospores were present. The absence of zygospores would exclude the

second common species of *Absidia, A. spinosa* Lendner. The other specimen is from the Herbarium of Roland Thaxter and a pill box in the packet is simply marked "*Choanephora* on peach. Culture from E. D. Eddy. Jan. 1920." Examination of the second specimen showed fruiting material apparently on two strips of agar. The following is a description of this material: Colony low, dark gray to black with abundant sporangia; sporangiophores to 25 μ in diam. below the sporangium, hyaline, arising from the substrate mycelium, no septations or branches, walls smooth to slightly roughened, tapering upward then somewhat constricted below sporangia; rhizoids and stolons absent; sporangia with many spores, at first white then black, globose to slightly dorsiventrally flattened, borne nodding or circinately, 50–110 μ in diam.; sporangial wall dark gray and covered with minute spines or encrusted, breaking into two halves; columellae globose in smaller sporangia and pyriform in larger, smooth-walled, hyaline, with a collar, 20–42 × 20–52 μ in size; sporangiospores oval to elliptical and somewhat papillate at one or both ends, smooth-walled, contents uniform or granular appearing, 5.5–7.5 × 6.5–11 μ not including length of appendages; appendages of spores to 10 μ in length and 3 or 4 arising in a place; zygospores, conidia and sporangioles absent.

It is apparent that this specimen represents the type material, especially in view of Eddy's acknowledgment of valuable suggestions offered by Professor Roland Thaxter and the close resemblance of this specimen to the one described by Eddy in 1925.

A search for living material of this species located a culture at the Centraalbureau voor Schimmelcultures, Baarn, Holland, listed as *C. persicaria* Eddy, deposited by Jacobs. Correspondence with the Baarn Collection disclosed that this culture had been brought to their Collection by a Miss C. Jacobs, who visited their laboratory in 1932 and who had come from Harvard. Furthermore, the culture was "isolated from peach." This strain, carried as NRRL 2700 in our Collection, appears to be identical with the type material described above.

When it appeared that NRRL 2700 was actually Eddy's original strain which had attacked peaches, the following experiment was made to determine whether or not it was still pathogenic to peaches. Ripe peaches bought in a local market were selected for their lack of any bruises or skin breaks. After the surfaces were carefully sterilized, the following procedures were used to inoculate the peaches: (1) Spores were laid on the skin without any injury to the fruit, (2) slices were made sufficiently deep to insert the mycelium and the skin flap was pressed back into place, (3) a fine needle dipped in the spores was used to puncture the surface once, and finally (4) for control some peaches were not inoculated in any fashion. All peaches were placed in moist chambers. By the end of 3 days, infection appeared

in treatments 2 and 3 as large, firm, brown discolored areas about the site of inoculation. At 4 days sporangia were appearing on those showing decay in 3 days. Photographs of a control peach and one inoculated with a single puncture are shown in Figure 1.

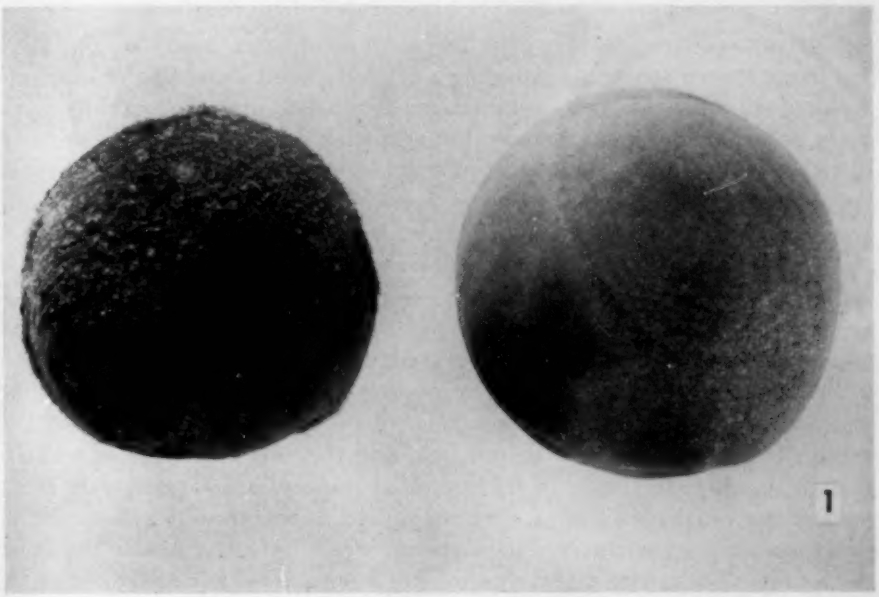

FIG. 1. Peach infected with *Gilbertella persicaria*. The peach on the left inoculated with spores by a single puncture while the peach at the right is an uninoculated control.

When the experiment was terminated at 11 days, observations were as follows: Neither the untreated controls nor the peaches treated with spores placed on their intact skins showed infection. All peaches used in treatments 2 and 3 had decayed and were covered with sporangia over their entire surfaces. The rot was strikingly different from that caused by *Rhizopus* in that there was no aerial mycelium, but the peaches were covered rather uniformly with sporangiophores. The flesh was completely brown in color but firm, and the shapes of the peaches were retained. No evidence of leak was observed. The skin could not be peeled from the fruit. Later, peaches inoculated by puncture and not placed in a moist chamber, likewise rapidly rotted. Thus, the infection was proved to be similar to that described by Eddy. When pieces of tissue were aseptically removed, pure cultures of *C. persicaria* were readily isolated, and mycelium could be seen in thin sections of peach tissue under the microscope. It appears almost certain that this strain is the type and has retained its morphology as well as its infectivity since 1918.

Gilbertella Hesseltine gen. nov.[1] Sporangiophora plerumque simplicia, sporangia circinata disposita ferentia; tunica sporangiorum in dimidia fracta; columellae plerumque pyriformes; sporangiosporae utrimque appendiculas singulas hyalinas ferentes; nulla conidia vel sporangiola; zygosporae aeriae, in zygophoris inter suspensores parallelos consimilesque lati, superficie processibus ut in *Mucore* exasperatae; heterothallica.

Mycelium coarse, rapidly growing; sporangiophores mostly simple, bearing many-spored sporangia; sporangia often borne in a nodding or circinate fashion, splitting into two equal halves; columellae present, typically pyriform in larger sporangia; sporangiospores with several hyaline appendages at either end of the sporangiospore; without sporangioles or conidia; zygospores formed aerially on zygophores, between parallel and equal suspensors, roughened with projections as in *Mucor;* heterothallic.

Type: *G. persicaria* (Eddy). *Gilbertella* has the same characteristics found in *Choanephora* and *Blakeslea* except that no conidia or sporangioles are formed. One species of *Choanephora, C. circinans,* also lacks conidia and sporangioles. However, *Gilbertella* is strikingly different from the members of the Choanephoraceae in having zygospores formed in a typical *Mucor*-like manner on zygophores above the surface of the substrate. *Choanephora* has zygospores formed in or on the medium and they are relatively smooth although showing striations. In *Gilbertella* zygospores are covered with large projections which give them a very roughened appearance and there are no striations on their surfaces. The suspensors in *Gilbertella* are of the same size and parallel to each other, whereas in *Choanephora* they are coiled about each other at the base, then bend apart to bear the zygospores between the suspensors like the jaws of a pair of tongs. For these reasons it appears necessary to designate this species as a new genus. It is named in honor of the late Professor E. M. Gilbert of the University of Wisconsin, who first introduced the author to the study of the Mucorales and who so ably pointed out the need for a systematic study of this large and interesting group of fungi.

Judging from the characteristics possessed by this monotype genus one is forced to conclude that it represents a form intermediate between the Mucoraceae and the Choanephoraceae and especially between *Mucor* and *Choanephora.* If the concept is accepted that the sexual stage of fungi is more important than the asexual stage in determining natural relationships, one is forced to conclude that this genus belongs in the family Mucoraceae and that the concept of the family Mucoraceae must be enlarged to include forms which possess sporangiospores with appendages.

Gilbertella persicaria (Eddy) Hesseltine nov. comb. *Choanephora persicaria* Eddy. 1925. Phytopath. **15**: 610.

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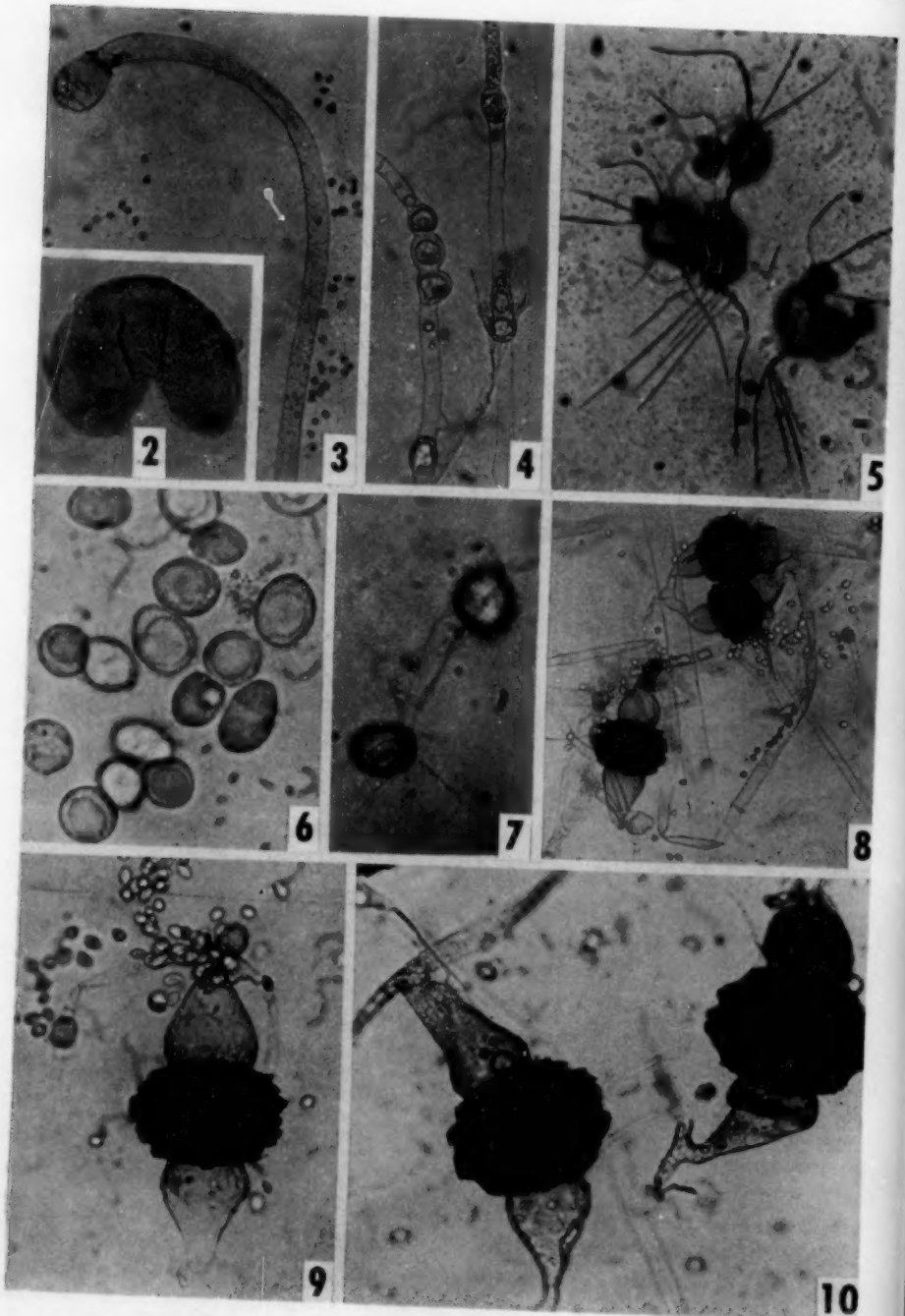
[1] The author would like to express his sincere appreciation to Dr. C. R. Benjamin for preparing the Latin description of *Gilbertella.*

[2] Colors, where capitalized, are those used by Ridgway (1912).

Colonies on synthetic *Mucor* agar (SMA) growing rapidly at 25–26°C., at 6–9 days some strains covering the agar in Petri dishes, while others remain restricted, from 3–6 mm. in height, possessing little to a strong yeast- or *Mucor*-like odor; colonies at first white then Grayish Olive,[2] Dark Neutral Gray, Dark Olive-Gray or Dark Mouse Gray, varying from brown to black in color and sometimes with the gross appearance of low *Rhizopus* colonies; under a dissecting microscope colonies appear moist due to the release of sporangiospores, sometimes with aerial mycelium mixed in with sporangiophores; colony reverse Deep Olive-Buff, Light Olive-Gray, Olive-Buff, Tea Green or Vetiver Green, in age Dark Olive-Buff; sporangiophores arising mostly from substrate mycelium, often covered with droplets of exudate, hyaline below, light brown to grayish blue above, not septate, enlarging gradually above to the region of the curvature and then reduced in diameter just below the sporangium, often minutely roughened below sporangium, typically unbranched, erect although in age sometimes appearing collapsed, up to 40–50 μ in diam. in the widest region, up to 3–4 mm. in height, not phototrophic; sporangiophores feel rotten when being removed with a transfer needle, and when very old on malt agar, are rough and quite yellow brown in color; rhizoids and stolons absent; sporangia at first white, then yellow or amber and when mature black and glistening, globose to somewhat dorsiventrally flattened or irregularly globose, many-spored, borne erect or more typically borne circinately or nodding, 40–260 μ in diam.; sporangial wall granular and minutely roughened (fig. 2), light brown to bluish or purplish gray, transparent, breaking into two equal pieces from the top to attachment of sporangiophore, in some strains some sporangia appear to deliquesce; columellae 40–119 $\times$ 20–170 μ (fig. 3), variable in shape depending on size, smallest applanate, larger oval or cylindrical and largest regularly pyriform; columellae hyaline, light brown or bluish or purplish gray, smooth-walled, empty or with yellow oil droplets or granular material, with small collar; sporangiospores (figs. 5, 6, 7) 5–13 $\times$ 4.5–11 μ, up to 8.6 $\times$ 17 μ, globose spores 5–13 μ in diam., short oval, oval and rather irregular in shape with a papilla at either end, hyaline, thin-walled, smooth-walled, with one or more colorless droplets inside with appendages; appendages from papillae 11–21 μ in length, hyaline, flexible, as many as 4–5 typically arising from both ends of the spore; chlamydospores 14–28 $\times$ 20–32 μ (fig. 4), sometimes as small as 12 $\times$ 14 μ, present in aerial mycelium, occasionally in sporangiophores and usually very abundant in substrate mycelium, typically intercalary, solitary or in chains, cylindrical, oval, globose or irregular, often same diameter as hyphae but others larger, thick-walled, hyaline or faintly yellow-colored walls, contents granular or with oil droplets; zygospores (figs. 8, 9, 10) formed as a solid black line across the plate at juncture of two mating types, borne in air above substrate, never on or in sub-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strate; zygospores 35–90 μ, mostly 70–80 μ in diam., globose or compressed between the suspensors, golden brown or brown in color but singly never black, covered with blunt or sometimes sharp-pointed projections, projections often irregular and up to 6 μ in length; suspensors 30–57 μ in larger region, roughened, equal, light brown, swollen and then constricted next to the zygospore, only about 10 μ in diam. at attachment to zygophore where occasionally a septum may occur, sometimes covered with crystals; heterothallic; zygophores 10–15 μ in diam., arising from substrate mycelium, bearing zygospores in a ladder-like fashion at same time sporangia are formed, sometimes with chlamydospores, hyaline, always roughened and reaching the height of sporangiophores.

Type: The specimen in the Farlow Herbarium of the Thaxter Collection, Accession No. 188, marked "*Choanephora* on peach. Culture from E. D. Eddy. Jan. 1920." The type culture is NRRL 2700 which almost certainly is a living culture derived from the Eddy isolation. This is the Jacobs' strain in the Baarn, Holland Collection.

The above description is a composite one based on 17 strains available for study as well as the type material. The source and mating reaction of the isolates studied are as follows:

Reaction	*Number*	*Source*
−	NRRL 1546	Isolated from Texas soil by M. B. Morrow, 1940.
−	NRRL 1556	Received as *Blakeslea trispora* in 1940 from L. H. Leonian.
+	NRRL 2352	Dayton Trickling Filter Plant. Isolated by W. B. Cooke, 1952.
+	NRRL 2357	Dayton Trickling Filter Plant, Imhoff sludge. Isolated by W. B. Cooke, 1952.
−	NRRL 2700	From Centraalbureau voor Schimmelcultures, Baarn, Holland, originally from Miss Jacobs.
−	A-2494	From soil sample from O. Mallea, Tucuman, Argentina. 1949.
+	A-6311	From T. Campbell, University of Tennessee, from rotted peach, 1955.
+	A-6597	Isolated from soil sample under banyan tree, Panama City, 1956.
+	A-6598	Same as A-6597.
−	A-6599	Isolated from sandy soil from Rio de Janeiro, Brazil, 1956.
+	A-6600	Isolated from soil from Rio de Janeiro, Brazil, 1956.
−	A-6601	Same as A-6600.
+	A-6602	Same as A-6600.
−	A-7313	Isolated from decaying mulberries, Brighton, Iowa, July 1957.
+	A-7314	Same as A-7313.
−	A-7315	Same as A-7313.
+	A-7316	Same as A-7313.

FIGS. 2–10. *Gilbertella persicaria*. FIG. 2. One half of the sporangial wall. FIG. 3. Upper portion of sporangiophore showing typically curved region and columella. FIG. 4. Chlamydospores. FIG. 5. Appendages of sporangiospores stained with Leifson's flagella stain. FIG. 6. Sporangiospores as usually seen in water mounts. FIG. 7. Sporangiospores showing appendages from water mount. FIG. 8. Zygospores. FIG. 9. Zygospores showing ornamentation of the zygospore wall. FIG. 10. Mature zygospores.

The media used in this study were similar to those used in other studies on Mucorales from this laboratory. The above description is based on studies of strains grown on SMA, except for the portion on the sexual stage which is based on studies of mated cultures grown on potato dextrose agar (PDA). Each of the above strains was studied on several additional media. On Czapek's solution agar, growth is thin, although sporulation does occur. On PDA, colonies are yellow brown or black depending on the strain, with excellent sporulation and with the agar in Petri dishes completely covered in less than 5 days. On malt agar sporulation is excellent and the plates are covered with growth in 5 days. On every medium the colonies are very low, never exceeding 5–6 mm. in height. Chlamydospores are formed on all media.

The curious appendages on the sporangiospores of *G. persicaria* can be seen in every strain, although they cannot be seen on every spore. Appendages can be demonstrated very well, when Leifson's flagella strain (1951) diluted 1:10 in distilled water is added to mounts made with 70% alcohol. Appendages are also clearly visible when water mounts are prepared and the Leifson stain is added at the edge of the cover slip. By careful study of water mounts, using an oil immersion objective, one also can see the appendages. Another method is to allow the mount to dry out gradually, at which time the appendages break through into the air and are clearly visible. Spores mounted in a dry condition clearly show the appendages, as well as when mounted in agar. If the spores are germinated on nutrient agar, they enlarge and typically put forth a single germ tube which proliferates variously to give short branches.

The sporangia characteristically break into halves in an undisturbed condition in culture. The halves of the sporangial wall remain attached and the sporangiospores push outward as a mucus-like mass. When the sporangia dry in place the two halves of the walls return to almost their original position, but show a lighter-colored region between them where the two halves do not quite meet.

The isolates of this species can be divided into two groups on the basis of the colony appearance. One group produces colonies having a definite black color due to heavy sporulation. This is true whether one uses malt agar or PDA and presumably would also be true on other media. The second group (NRRL 2700, A-6602, A-6597, A-6598, A-7313, and A-7315) have considerably more white aerial mycelium, and their colonies have a brownish tint due to the color of the sporangia, although black sporangia are present as in the first group. There is no correlation between sex and color, since in the brown group 3 are plus and 3 are minus. Each of the two groups freely mates with opposite types of the other group and therefore no taxonomic recognition is felt necessary of the separate color forms.

When strains of *G. persicaria* were mated in various combinations on

PDA at 25°C., every strain produced zygospores with its appropriate mating type. When strains NRRL 1546 and NRRL 2352 were compared with *Blakeslea trispora* NRRL 2456 and NRRL 2457, it was found that a sexual reaction would occur between the two species on PDA, enabling one to designate all isolates of *G. persicaria* either plus or minus. It was found that *G. persicaria,* when mated on PDA at various temperatures, produced zygospores at 20, 25, 28, and 32°C., but not at 37°C. or above. Plates incubated at 15°C. for two weeks showed no zygospores. At 37°C. growth occurred, but the colonies were devoid of sporangia, and at 42°C. no growth occurred. It should be noted that at 25°C. the line of union of opposite mating types, as seen on the reverse side of a Petri dish, showed only a slight amount of yellow color. The yellow color in this zone became progressively more yellow as the temperature of incubation was elevated to 32°C. When mated strains are grown at 28°C. on a shaker using the synthetic *Mucor* ingredients but omitting the agar, yellow orange mycelium is produced in the mated flasks. This material was given to Miss Margie Arnold, who determined it to be beta-carotene. Thus the situation here resembles that found in the Choanephoraceae. Cultures similarly mated and grown on potato dextrose broth on a shaker resulted in single solid flattened masses of mycelium which showed some sporangia on their upper surface. Perfectly normal zygospores were formed, as is also found with the Choanephoraceae.

Since *Gilbertella* shows many relationships to members of the Choanephoraceae, the mating types of *Blakeslea trispora* NRRL 2456 and NRRL 2457 were contrasted with *G. persicaria* NRRL 2352 and NRRL 1546 on PDA at 25°C. In the combination, NRRL 2352(+) × 2457(−), a great amount of proliferation of hyphae occurred where the strains came together and there was an accumulation of yellow orange pigment in this mycelium in this area. No recognizable stage of zygospore formation was seen. However, in the combination, NRRL 1546(−) × 2456(+), the same color formed and, in addition, zygospores similar to those seen in *Gilbertella* were formed in large numbers. They occurred in the aerial mycelium, had suspensors parallel to each other, and had zygospores covered with projections. Not only did they look typical of the zygospores of *Gilbertella,* but they were brown in color and often appeared quite normal in appearance.

A species which shows some resemblance to *Gilbertella* is *Mucor saturninus* Hagem. This species, however, has no appendaged sporangiospores and its sporangia do not split into two halves at maturity. When mating types of *G. persicaria* were mated with it, no sexual reaction occurred, indicating that the two were not closely related. When *G. persicaria* mating types were contrasted with *Mucor mucedo* Brefeld, no sexual reaction was observed.

SUMMARY

1. *Choanephora persicaria* Eddy has been rediscovered and studied from the type material as well as from a number of strains isolated from soil, sewage, peaches, and mulberries.

2. The zygosporic stage has now been found and its development proves conclusively that this fungus represents a new genus, *Gilbertella*. This genus is heterothallic, possessing a *Mucor*-like sexual stage and a *Choanephora*-like asexual stage. From a study of the life cycle it is concluded that *Gilbertella* is a form intermediate between the Mucoraceae and Choanephoraceae.

3. When + and – strains are brought together, they can produce zygospores in liquid media and form beta-carotene.

4. *Gilbertella* can cause a brown, firm type of rot in peaches with abundant sporulation over the surface of the fruit.

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VOL. 87, No. 1, pp. 31–45 JANUARY, 1960

DESCRIPTIONS OF TROPICAL RUSTS—IX[1]

GEORGE B. CUMMINS

There are 54 species of the Uredinales included, of which 38 are described as new, 12 are proposed as new combinations, and supplementary notes are provided for 4. Of the 38 new species, 31 are from Africa, 3 are from the Philippines, and 1 each is from the United States, Mexico, Ecuador, and New Guinea.

Achrotelium rhodesicum sp. nov. Urediis hypophyllis, in maculis aggregatis, flavidis, rotundatis, 0.1–0.3 mm. diam.; urediosporis ellipsoideis vel late ellipsoides, (14–)17–20(–21) × (23–)26–33(–36) μ; membrana 2 μ crassa, hyalina, echinulata; poris germinationis obscuris. Teliis conformibus sed compactis; teliosporis cylindraceis, 12–15 × (30–)34–50(–55) μ, statim a maturitate germinantibus; membrana 1–1.5 μ crassa, hyalina, levi; pedicello hyalino, tenui, usque 30 μ longo.

Type: On *Voacanga angolensis* Stapf, Fort Roseberry Dist., Western Prov., N. Rhodesia, 1952, *F. White F6* (K).

This species differs from *A. ichnocarpi* Syd., the only other species on Apocynaceae, in having shorter teliospores. There are 3 other species, 1 each on the Asclepiadaceae, the Sapotaceae, and the Urticaceae.

Aecidium dyschoristes sp. nov. Spermagoniis caulicolis, globosis, 65–165 μ diam., subepidermalibus. Aeciis in gregibus usque 3 cm. longis dispositis, cupulatis, 200–350 μ diam., margine lacerato, cellulis peridii plus minusve oblongis, 14–20 × 24–38 μ, pariete interiori 3–3.5 μ crasso, rugoso, exteriori 4–6 μ crasso, striato; aeciosporis angulariter ellipsoideis vel globoideis, (14–)16–20(–22) × (17–)19–26(–28) μ; membrana 1–1.5 μ crassa, hyalina, verrucosa.

Type: On *Dyschoriste perrottetii* (Nees) Kuntze, Samaru, Zaria, northern Nigeria, April 1957, *E. Harrison 16* (IMI, PUR).

The caulicolous habit distinguishes this fungus from *A. traceanum* Syd., the only other species on the genus *Dyschoriste*.

Aecidium gomphocarpi sp. nov. Spermagoniis subepidermalibus, globosis, usque 125 μ diam. Aeciis hypophyllis vel caulicolis, in maculis interdum leniter incrassatis, usque 2 cm. longis aggregatis, cupulatis, margine albido lacerato; cellulis peridii plus minusve rhomboideis, 15–19 × 23–30 μ, pariete interiori 3 μ crasso, rugoso, exteriori 3–5 μ crasso, striato; aeciosporis globoideis vel ellipsoideis, (13–)15–17(–18) × (15–)17–20(–24) μ; membrana 1 μ crassa, hyalina, subtilissime verrucosa.

Type: On *Gomphocarpus fruticosus* (L.) R. Br., Mt. Mukulu Research Station, near Chilanga, N. Rhodesia, Dec. 17, 1956, *A. Angus M202* (IMI, PUR).

A fragmentary specimen on the same host plant from South Queensland,

[1] Journal Paper No. 1475 of the Purdue University Agricultural Experiment Station. The help of Miss Edith K. Cash with the Latin descriptions is gratefully acknowledged.

Australia (Langdon No. 233) differs in having aeciospores that are 22–29 μ long.

Aecidium multisorum sp. nov. Spermagoniis non visis. Aeciis plerumque hypophyllis, ubique aequaliter distributis, 0.2–0.3 mm. diam., margine lacerato recurvato, cellulis peridii firme conjunctis, hyalinis vel flavidis, oblongis vel oblongo-ellipsoideis, 16–22 × 25–33 μ, pariete interiori 2–3.5 μ crasso, rugoso, exteriori 3.5–6 μ crasso, punctato-striato; aeciosporis oblongo-ellipsoideis vel fere globosis, 12–16 × 14–20 μ; membrana 0.5–1 μ crassa, hyalina, verrucosa.

On *Clerodendron uncinatum* Schinz, Citedzi, Lilongwe district, Nyasaland, Sept. 22, 1951, *G. Jackson* (comm. Wiehe No. 1111) Type (IMI, PUR); Chalimbana, 14 miles east of Lusaka, N. Rhodesia, June 20, 1956, *A. Angus M173.*

A similarly systemic species, *A. nairobianum* Cumm., occurs in Kenya on *Lippia asperifolia* Rich. but it has larger spores (13–22 × 21–33 μ).

Aecidium phaylopsidis sp. nov. Spermagoniis amphigenis, subepidermalibus, globosis, 140–170 μ diam. Aeciis hypophyllis, in maculis usque 2 cm. diam. laxe aggregatis, cupulatis, plus minusve 0.2 mm. diam., albidis, margine lacerato; cellulis peridii plerumque oblongo-ellipsoideis (14–)17–20 × 26–35 μ, pariete interiori 2.5–3.5 μ crasso, rugoso, exteriori 3–5 μ crasso, striato; aeciosporis late ellipsoideis vel globoideis, (15–)17–20 × 19–25 μ; membrana hyalina, 1 μ crassa, subtilissime verrucosa.

Type: On *Phaylopsis falcisepala* C. B. Cl., Njala (Kori), Sierra Leone, Nov. 28, 1928, *F. C. Deighton M217* (IMI, PUR).

This rust, previously referred to *A. acanthinum* Har. & Pat. (1909, not Spegazzini 1899), was reported originally on *Mimulopsis violacea* Lindau (= *M. solmsii* Schweinf.), *Phaylopsis barteri* T. Anders., and *P. micranthus* C. B. Cl. from Oubangui-Chari, French Equatorial Africa. The type was not designated. The Sydows (Monogr. Ured. **4**: 97. 1923) selected the collection on *Mimulopsis* but they stated that the spores were nearly double the size given by Hariot and Patouillard. A new name is necessary but *A. acanthinum* should be treated as a *nomen confusum* and not as a synonym of *A. phaylopsidis.*

A. phaylopsidis occurs also on *P. barteri* T. Anders. and *P. imbricata* Cordem. (*P. parviflora* Willd.) in Ghana and Sierra Leone.

Aecidium rhodesicum sp. nov. Spermagoniis epiphyllis, subepidermalibus, globosis, 75–120 μ diam. Aeciis amphigenis, in maculis usque 1 cm. diam. aggregatis, aeciis individuis 0.15–0.3 mm. diam; cellulis peridii plus minusve oblongo-ellipsoideis, 15–20 × 20–28 μ, pariete exteriori punctato-striato, 3–3.5 μ crasso, interiori rugoso, 2.5–3 μ crasso; aeciosporis ellipsoideis vel globoideis, 13–16 × 16–20 μ; membrana 0.5–1 μ crassa, minuteque verrucosa.

Type: On *Eupatorium africanum* Oliver & Hiern, S. Rhodesia, received at Commonwealth Mycological Institute Jan. 1953, *A. Rothwell MR11203* (IMI, PUR).

The specimen is not in good condition but the aecia are bullate with a peridium that is scarcely exserted and breaks at the surface of the host.

Chaconia coaetanea (Syd.) comb. nov. (*Desmotelium coaetaneum* Syd. Ann. Mycol. **35**: 253. 1937).

I have recently (Illustrated Genera of Rust Fungi. 131, pp. Burgess Publ. Co. 1959) treated *Desmotelium* as a synonym of *Chaconia* but the species was not transferred.

Crossopsora perscita sp. nov. Status urediosporiferus *Uredo perscita* Cumm. Teliis hypophyllis, sparsis vel aggregatis, filiformibus, usque 7 mm. longis, 35–100 μ diam., brunneis; teliosporis oblongis vel cylindraceis, 10–16 × 30–65 μ, statim a maturitate germinantibus; membrana 1.5 μ crassa, aureo-brunnea, levi.

Type: On *Vernonia aurantiaca* (O. Hoffm.) N. E. Br., Shamra, S. Rhodesia, June 11, 1956, *A. Rothwell MR14032* (IMI, PUR).

The uredia are rare but correspond to *Uredo perscita* on *Vernonia amygdalina* Delile in Uganda.

Dicheirinia trispora sp. nov. Spermagoniis epiphyllis, subcuticularibus, conicis, usque 70 μ diam. Teliis hypophyllis, subepidermalibus, erumpentibus, plerumque circinatim dispositis, brunneis, usque 0.3 mm. diam., sine paraphysibus; teliosporis 3-cellularibus, triangularibus, 30–40 μ latis, 26–34 μ altis, quaque cellula poro germinationis unico apicali praedita; membrana cinnamomeo-brunnea, 1.5–2 μ crassa, uniformiter verrucosa; pedicello hyalino fragili.

Type: On *Abrus precatorius* L., Beau Vallon, Mauritius, Aug. 9, 1957, *G. Orian* (comm. Felix *D/444*) (IMI, PUR).

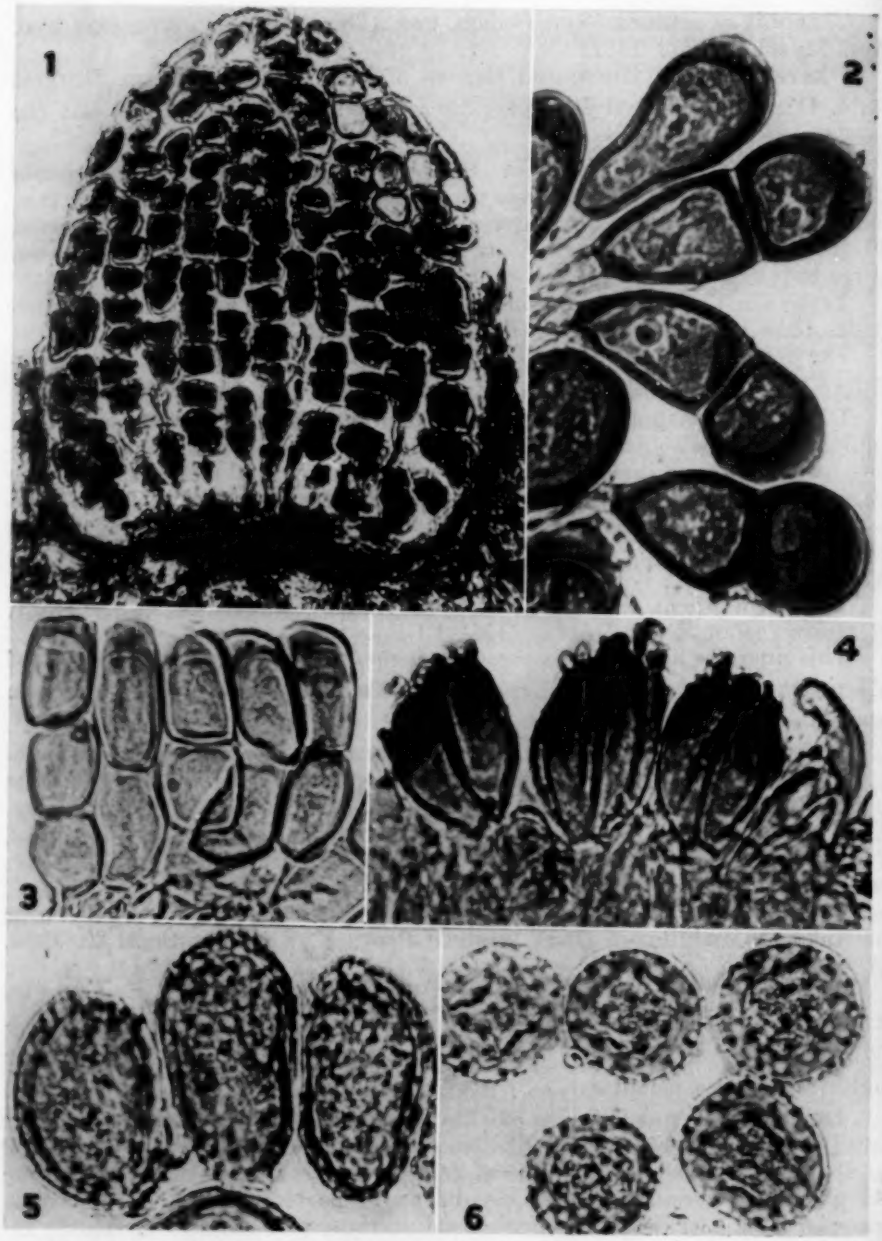
This microcyclic species is the first *Dicheirinia* reported on a species of *Abrus*. It and *D. canariensis* Urries on *Cytisus* are the only extra-American species.

Didymopsora africana sp. nov. (fig. 1). Spermagoniis epiphyllis, subepidermalibus, globosis, 100–150 μ diam. Teliis hypophyllis, in maculis usque 8 mm. diam. aggregatis, erumpentibus, 0.15–0.3 mm. latis, usque 0.5 mm. altis, brunneis vel pallidis, compactis; teliosporis oblongo-ellipsoideis, (17–)19–22(–24) × (29–)33–45(–48) μ, statim a maturitate germinantibus; membrana 1 μ crassa, hyalina, levi.

Type: On *Dissotis* sp., near headwaters of the Lunga River, 5 miles west of Kakoma, Mwinilunga Dist., Western Prov., N. Rhodesia, Sept. 30, 1954, *A. Angus M76* (K, PUR).

This is the first African record of *Didymopsora* and the first species known to parasitize the Melastomataceae. *Pucciniosira dissotidis* (Cke.) Wakef. occurs on *Dissotis* in Africa. *Pucciniosira* differs from *Didymopsora* only in having a peridium.

Diorchidium quadrifidum sp. nov. (fig. 4). Spermagoniis, aeciis, et urediis ignotis. Teliis hypophyllis, sparsis, erumpentibus, brunneis, 75–150 μ diam.; periphysibus hyalinis vel flavidis, incurvatis, 6–12 μ latis, usque 45 μ longis, deorsum coalitis; membrana in parte interiori 1–2 μ crassa, exteriori 4–6 μ crassa; teliosporis 4-cellularbus, plerumque ellipsoideis vel oblongo-ellipsoideis, (16–)18–23(–25) × (28–)30–37(–39) μ, ad apicem digitato-coronatis, quaque cellula poro germinationis unico apicali praedita, statim a maturitate germinantibus; membrana ad apicem 2–4 μ crassa,



Figs. 1–6. Fig. 1. Stained longitudinal section of a telium of *Didymopsora africana* Cumm. Fig. 2. Teliospores of *Puccinia oncidii* Cumm. Fig. 3. Teliospores of *Physopella nyasalandica* Cumm. Fig. 4. Section of a telium of *Diorchidium quadrifidum* Cumm. Fig. 5. Urediospores of *Uredo tillandsiae* Cumm. Fig. 6. Urediospores of *Uredo pieningii* Cumm. All photos from types. Fig. 1 × 250; Figs. 2–6 × 800.

castaneo-brunnea, deorsum 1 μ crassa, pallidiori, levi; pedicello hyalino, tenui, persistenti, usque 35 μ longo.

Type: On *Dalbergia afzeliana* G. Don, between Takoradi and Agona, Ghana, Nov. 2, 1957, *R. I. Leather CB2612* (IMI, PUR).

A few collapsed urediospores were seen. They were reniform or "mitten-shaped" in one view and obovoid when rotated 90 degrees, measured 13–18 × 19–23 μ, were cinnamon-brown, echinulate, and had 4 equatorial germ pores.

This and the following species could be considered to represent a new genus, because of the 4-celled teliospores, but it would differ from *Diorchidium* only in this character. I prefer to treat these fungi as species of *Diorchidium* in the belief that a series of species, having radially arranged vertically septate teliospores with simple pedicels and 1 germ pore in each cell, may be anticipated. The addition of 1 or a few cells to a teliospore does not justify a new genus.

Diorchidium tetrasporum sp. nov. (fig. 15). Spermagoniis et aeciis ignotis. Urediis hypophyllis, sparsis vel laxe aggregatis, usque 0.4 mm. diam., cinnamomeo-brunneis; periphysibus hyalinis vel flavidis, incurvatis, 7–10 × 40–75 μ, deorsum coalitis et septatis; membrana 2–3.5 μ crassa; urediosporis asymmetricis, obovoideis 15–20 μ latis vel reniformibus 12–16 μ latis, (23–)25–30(–33) μ longis; membrana 1–1.5 μ crassa, cinnamomeo-brunnea, echinulata; poris germinationis 4, superaequatorialibus. Teliis non visis; teliosporis 4-cellularibus, ellipsoideis vel oblongo-ellipsoideis, (15–)17–20(–22) × (30–)32–38(–40) μ, quaque cellula poro germinationis unico apicali praedita, statim a maturitate germinantibus; membrana ad apicem 2–3 μ crassa, deorsum 1 μ crassa, aureo-brunnea, levi; pedicello hyalino, tenui, persistenti, usque 40 μ longo.

Type: On *Sphenostylis erecta* (Bak. *f.*) Hutch. ex Bak. *f.*, near Chilanga, Mt. Makulu Research Station, N. Rhodesia, Apr. 14, 1958, *A. Angus M543* (IMI, PUR).

Goplana dioscoreae sp. nov. (*Goplana dioscoreae* Cumm. Mycologia 27: 607. 1935, *nom. nudum*). Status urediosporiferus, *Aecidium dioscoreae* Berk. & Br. (*Uredo dioscoreae-alatae* Racib.) Teliis hypophyllis, aggregatis, subepidermalibus, erumpentibus, gelatinosis, flavidis; teliosporis cylindraceis, 8–10 × 46–60 μ; membrana hyalina, 0.5 μ crassa.

Type: On *Dioscorea alata* L., near Manila, Luzon, Philippine Islands, Dec. 2, 1912, *P. W. Graff* (Sydow, Fungi exotici exsiccati No. 230 as *Uredo dioscoreae-alatae* Racib.).

Hapalophragmium ornatum sp. nov. (fig. 12). Spermagoniis epiphyllis, subcuticularibus, conicis, 85–115 μ diam. Aeciis plerumque epiphyllis uredinoideis; periphysibus incurvatis, bi- vel tri-septatis, hyalinis vel flavidis, 6–9 μ latis, usque 100 μ longis; membrana in parte interiori 1–1.5 μ crassa, in parte exteriori 2.5–4.5 μ crassa; aeciosporis asymmetricis, reniformibus, 11–14 × 19–21 μ vel obovoideis, 15–19 × 21 μ; membrana 1 μ crassa, cinnamomeo-brunnea, echinulata; poris germinationis 3 (vel 4?), aequatorialibus. Urediis et teliis ignotis; teliosporis 3-cellularibus, 22–29 × 27–36 μ, appendiculis brunneis plus minusve truncatis, 3–5 μ altis, obsitis; membrana 1–1.5 μ crassa, castaneo-brunnea; pedicello hyalino, 10–18 μ longo.

Type: On *Millettia* sp., Mampong, Ashanti, Ghana, Apr. 29, 1956, *L. Piening CB2349b* (IMI, PUR).

The teliospores are more coarsely sculptured than in other species. The spores of *H. ornatum* are uniformly sculptured but the ornamentation is over the germ pore in *H. setulosum* (Pat.) Syd. The 3 species previously described on *Millettia* are not ornamented.

Hapalophragmium pieningii sp. nov. (fig. 13). Urediis hypophyllis, sparsis, subepidermalibus, poro centrali apertis, 100–150 μ diam.; periphysibus copiosis, deorsum coalitis, incurvatis, frequenter 1-septatis; membrana hyalina vel aureo-brunnea, parte interiori 1–2 μ crasso, exteriori 3–6 μ crasso; urediosporis ellipsoideis vel obovodeis, 20–23 × (23–)25–27(–29) μ; membrana 1–1.5 μ crassa, flavida vel aureo-brunnea, echinulata; poris germinationis 3, aequatorialibus. Teliosporis in urediis plus minusve triangulariter 3-cellularibus, (12–)17–23(–26)×(33–)36–42(–45) μ, statim a maturitate germinantibus; membrana 0.5–1.0 μ crassa, hyalina, levi; pedicello hyalino, 6–12 μ longo.

Type: On *Dalbergiella welwitschii* (Baker) Baker *f.*, Kumasi, Ghana, Apr. 2, 1956, *L. Piening CB2300* (IMI, PUR).

The teliospores are delicate and germinate by the continued growth of the apex of each spore. The spores are clustered on sporogenous basal cells.

Hemileia mussaendae Viennot-Bourgin sp. nov. Status urediosporiferus. *Hemileia mussaendae* Viennot-Bourgin. Teliis hypophyllis, minutis, partes majores foliorum dense aggregatis, flavidis, per stomata erumpentibus; teliosporis levibus, angulato-globosis vel varie lobatis, 14–26 μ diam., statim a maturitate germinantibus; membrana 0.5–1.0 μ crassa, hyalina.

Type: On *Mussaenda* sp., Wenchi, Ashanti, Ghana, Nov. 25, 1955, *L. Piening CB2129* (IMI, PUR).

Since Viennot-Bourgin's fungus on *Mussaenda erythrophylla* Schum. & Thonn. from Ivory Coast had no teliospores the name, *H. mussaendae*, dates from the present publication and Piening's specimen is the type.

The superstomatal sporogenous cells are produced from the apical enlargement of a single feeder hypha, hence the species belongs to the "superstomatal B" type of Gopalkrishnan (Mycologia **43**: 271–283. 1951).

Hemileia ruspoliae sp. nov. Urediis hypophyllis, sparsis vel laxe aggregatis, flavidis, per stomata erumpentibus; urediosporis obovoideis vel plus minusve asymmetricis, 18–22 × 20–25 μ; membrana 1.5–2 μ crassa vel ad dorsum 2–3 μ crassa, hyalina, echinulata; poris germinationis obscuris. Teliosporis in urediis triangularibus, 17–20 × 22–26 μ, statim a maturitate germinantibus; membrana 0.5 μ crassa, hyalina, levi; pedicello brevi.

Type: On *Ruspolia hypocrateriformis* (Vahl) Milne-Redhead, Kpeve, Togoland, Ghana, Dec. 19, 1957, *L. Piening CB1461* p. p. (IMI, PUR).

This species, which has the "superstomatal A" type of sorus, is the first recorded on the Acanthaceae.

Miyagia clemensiae (Cumm.) comb. nov. (*Corbulopsora clemensiae* Cumm. Mycologia **32**: 365. 1940).

Miyagia gravida (Cumm.) comb. nov. (*Corbulopsora gravida* Cumm. Mycologia **32**: 365. 1940).

Miyagia cumminsii (Thirum.) comb. nov. (*Corbulopsora cumminsii* Thirum. Mycologia **39**: 235. 1947).

I have recently treated *Corbulopsora* Cumm. as a synonym of *Miyagia* (Illustrated Genera of Rust Fungi. 131 pp. Burgess Publ. Co. 1959) but no transfers were made.

Kuehneola harrisoniae Arth. & Cumm. sp. nov. (*K. harrisoniae* Arth. & Cumm. Philippine J. Sci. **61**: 472. 1936, *nom. nudum*). Teliis hypophyllis, minutis, sparsis, flavidis; teliosporis ex cellulis 5–10 compositis, cellulis cuboideis, 10–14 × 12–15 μ; membrana 1–1.5 μ, hyalina.

Type: On *Harrisonia perforata* (Blco.) Merr., Rosales and vicinity, Pangasinan Prov., Luzon, Philippine Islands, Feb. 1–14, 1925, *M. S. Clemens 5911* (PUR).

Phakopsora microspora sp. nov. Urediis hypophyllis, minutis, periphysibus incurvatis, hyalinis, 6–8 μ latis, 20–35 μ longis; membrana in parte interiori 1–1.5 μ crassa, in parte exteriori et apicali 2.5–4 μ crassa; urediosporis late ellipsoideis, 14–17 × 16–19 μ; membrana 1 μ crassa, hyalina vel pallide flavida, echinulata; poris germinationis obscuris. Teliis hypophyllis, subepidermalibus, plus minusve 100 μ diam., ex sporis irregulariter superpositis compositis; teliosporis oblongo-ellipsoideis vel oblongis, (6–)8–11(–13) × (8–)11–17(–20) μ; membrana flavida, 1–1.5 μ crassa, levi.

Type: On *Grewia carpinifolia* Juss., Biriwa, Ghana, Nov. 3, 1957, *L. Piening CB2620* (IMI, PUR).

This fungus has smaller urediospores and teliospores than *Phakopsora grewiae* (Pat. & Har.) Cumm. *Uredo corbiculoides* Cumm. has similar urediospores but much longer paraphyses.

PHRAGMIDIELLA AFRICANA Cumm. On *Stereospermum kunthianum* Cham., Kpeve, Togoland, Ghana, Dec. 18, 1957, *L. Piening CB1459*.

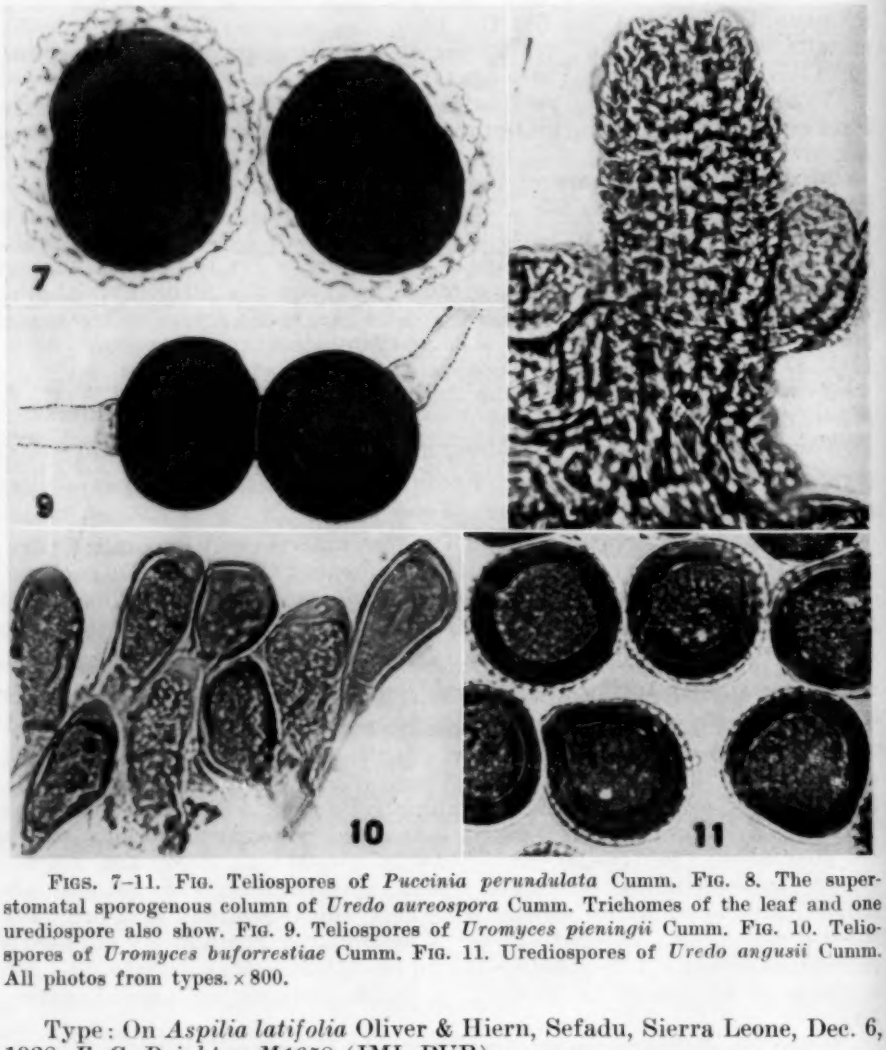
All spore stages are present. The spermagonia and uredinoid aecia, not described previously, are subcuticular, the former epiphyllous and the latter opposite the spermagonia in groups up to 3 mm. in diameter. The aeciospores are similar to the urediospores but the wall is about 2 μ thick or 3.5 μ apically.

Physopella nyasalandica sp. nov. (fig. 3). Urediis hypophyllis, sparsis, erumpentibus, flavo-brunneis, 0.1–0.2 mm. diam.; periphysibus incurvatis, 11–16 μ latis, usque 75 μ longis, hyalinis vel aureis, 1-septatis; membrana 1–2 μ crassa vel ad apicem 2–6(–8) μ crassa; urediosporis late ellipsoideis vel obovoideis, (16–)18–22(–23) × (21–)23–28(–31) μ; membrana 1–1.5 μ crassa, aureo-brunnea, echinulata; poris germinationis 6–8, sparsis, obscuris. Teliis hypophyllis, subepidermalibus, indehiscentibus, atro-brunneis, 0.2–0.4 mm. diam., ex sporis 2 vel 3 catenulatim compositis; teliosporis plerumque oblongis, (12–)14–16(–18) × (18–)22–26(–29) μ; membrana 1.5–2 μ crassa vel ad apicem (3–)4–6(–7) μ, lucide castaneo- vel aureo-brunnea, levi.

Type: On *Helichrysum* sp. (very possibly *H. petersii* Oliver & Hiern), Cholo, Nyasaland, Sept. 12, 1950, *P. O. Wiehe 879* (IMI, PUR).

The species is similar to *P. wiehei* (Cumm.) Cumm. & Ramachar on *Erlangea* but has shorter teliospores. *Erlangea* is in the Vernonieae; *Helichrysum* is in the Inuleae.

Puccinia aspiliae-latifoliae sp. nov. (*P. aspiliae-latifoliae* Cumm. Bull. Torrey Bot. Club **68**: 468. 1941. *nom. nudum*). Teliis non visis; teliosporis clavatis vel oblongo-ellipsoideis, 16–22 × (34–)38–52 μ; membrana 1–1.5 μ crassa, ad apicem 3–5 μ, flavida vel pallide aurea, levi; pedicello hyalino, tenui, spora breviori.



FIGS. 7–11. FIG. Teliospores of *Puccinia perundulata* Cumm. FIG. 8. The superstomatal sporogenous column of *Uredo aureospora* Cumm. Trichomes of the leaf and one urediospore also show. FIG. 9. Teliospores of *Uromyces pieningii* Cumm. FIG. 10. Teliospores of *Uromyces buforrestiae* Cumm. FIG. 11. Urediospores of *Uredo angusii* Cumm. All photos from types. × 800.

Type: On *Aspilia latifolia* Oliver & Hiern, Sefadu, Sierra Leone, Dec. 6, 1938, *F. C. Deighton M1658* (IMI, PUR).

PUCCINIA CESATII Schroet. On *Sorghum vulgare* Pers., Molo, Kenya, Jan. 1956, *R. M. Nattrass 1969*.

Only a few teliospores were seen but their characteristics, the aparaphy-

sate uredia, and the verrucose urediospores with 3 to 5 pores, indicate the fungus is *P. cesatii*. *P. cesatii* occurs on *Bothriochloa, Capillipedium,* and *Dichanthium* of the subtribe Andropogoninae but has not been reported on the subtribe Sorghinae.

PUCCINIA HAEMATITIS Syd. On *Triaspis stipulata* Oliver, Kumasi, Ghana, Jan. 19, Apr. 4, Apr. 19, 1956, *L. Piening CB2223, CB2320, CB2343.*

These collections are listed because they may be the first since the species was described (Bot. Jahrb. **45**: 260. 1910) on *T. auriculata* Radlk. from Uganda. The species is not in Wakefield and Hansford's (Proc. Linn. Soc. London, Session 161, **1948–1949**: 162–198. 1949) list of the Uredinales of Uganda.

Puccinia oncidii sp. nov. (fig. 2). Urediis hypophyllis, erumpentibus, rotundatis, 0.3–0.5 mm. diam., aggregatis; urediosporis plerumque late obovoideis, 22–26 × 26–30 μ; membrana 2(–3) μ crassa, cinnamomeo-brunnea, echinulata; poris germinationis 2 (vel 3), aequatorialibus. Teliis conformibus sed pulvinatis et compactis; teliosporis clavato-ellipsoideis, ad apicem rotundatis, 20–24 × (43–)46–58(–64) μ; membrana 2–3 μ crassa, ad apicem 4–7 μ, castaneo-brunnea vel aureo-brunnea, levi; poris germinationis in cellulis superioribus apicalibus, inferioribus juxta septum dispositis; pedicello hyalino, tenui, usque 50 μ longo, persistenti.

Type: On *Oncidium* sp., Mexico, 1957 (intercepted in customs, Miami, Fla., Aug. 21, 1957, Inspector A. S. Mills, Miami No. 4794) (BPI, PUR); Ecuador, 1958 (intercepted in customs, Miami, Fla., Jan. 7, 1958, Inspector B. P. Stewart, Miami No. 6036).

This fungus is similar to *Puccinia nasuensis* Hirat. *f.* but the apical wall of the teliospore of *P. nasuensis* is 10–17 μ thick. *P. cypripedii* Arth. & Holw. and *P. cinnamomea* Diet. & Holw. occur on orchids in the Americas but both have teliospores 45 μ or less in length.

Puccinia ophiopogonis sp. nov. (*P. ophiopogonis* Cumm. Ann. Mycol. **35**: 101. 1937, *nom. nudum*). Teliis non visis; teliosporis oblongis vel oblongo-clavatis, 16–20 × 35–55 μ; membrana cinnamomeo-brunnea, 2 μ crassa, ad apicem 3–5 μ crassa, levi; pedicello hyalino, spora aequante vel breviori.

Type: On *Ophiopogon japonicus* (L. *f.*) Ker., Mt. Santo Tomas, Benguet Subprov., Luzon, Philippine Islands, Mar. 26, 1935, *M. S. Clemens 51789* (PUR).

Puccinia perundulata sp. nov. (fig. 7). Urediis non visis; urediosporis plerumque ellipsoideis vel obovoideis, (17–)18–22(–24) × (22–)24–27(–30) μ; membrana 1–1.5 μ crassa, cinnamomeo-brunnea, echinulata; poris germinationis 2, aequatorialibus. Teliis hypophyllis vel inflorescenticolis, erumpentibus, sparsis, atro-brunneis, usque 0.4 mm. diam., plus minusve pulverulentis; teliosporis late ellipsoideis vel fere globosis, (33–)36–43(–45) × (39–)41–50(–53) μ; membrana bilaminata, lamina interiori 3 μ crassa, obscure castaneo-brunnea, lamina exteriori 3–7 μ crassa, flavida vel pallide aurea, undulato-striata vel undulato-reticulata; poris germinationis obscuris, in cellulis superioribus apicalibus, inferioribus verisimiliter prope hilum dispositis; pedicello hyalino, fragili, caduco.

Type: On *Dirichletia pubescens* Klotzsch, Munali Pass, Nega Hill, south of Kafue, N. Rhodesia, Apr. 4, 1957, *A. Angus M319* (IMI, PUR).

This fungus has *Uropyxis*-like teliospores with the outer portion of the bilaminate wall pale and somewhat hygroscopic. The exact sculpturing of the surface of the spore is obscure but seems to be a reticulum, with the primary ridges longitudinal and connected by cross ridges. The resulting shallow pits may be as much as 12 μ in diameter and can be observed best on immature spores. After complete pigmentation, the impression is that of a variously undulated surface.

Puccinia stenotaphri sp. nov. (*P. stenotaphri* Cumm. Bull. Torrey Bot. Club **72**: 213. 1945, *nom nudum*). Teliis amphigenis vel plerumque hypophyllis, subepidermalibus, indehiscentibus, atro-brunneis; teliosporis plerumque clavatis vel oblongo-clavatis, 19–26 × (37–)44–60 μ; membrana 1.5 μ crassa, ad apicem 2.5–4 μ crassa, castaneo-brunnea, levi; pedicello brunneolo, persistenti, 6–12 μ longo.

Type: On *Stenotaphrum dimidiatum* (L.) Brogn., Mauritius, about June 1938, *Wiehe 115* (IMI, PUR).

This species has been collected recently in Puerto Rico and southern Florida.

Ravenelia maranguensis sp. nov. (*R. maranguensis* Cumm. Bull. Torrey Club **72**: 215, 1945, *nom. nudum*). Teliis amphigenis sed plerumque epiphyllis, atro-brunneis; capitulis teliosporarum convexis, castaneo-brunneis, 80–135(–140) μ diam. 35 μ crassa, ex sporis 5–8 in partes omnes compositis, sporis marginalibus papillis 1–3(–6) subhyalinis tuberculiformibus obsitis; cystidiis hyalinis adpressis, eodem numero sporis marginalibus, in aqua diffluentibus; pedicello hyalino, ex hyphis pluribus composito.

Type: On *Indigofera* sp., Butandiga, Mt. Elgon, Uganda, Aug. 1934, *C. G. Hansford 1737* (K, PUR).

Sphenospora saphena sp. nov. Spermagoniis et aeciis ignotis. Urediis hypophyllis, in maculis usque 1.5 mm. diam. aggregatis, brunneis, rotundatis, 0.2–0.4 mm. diam.; urediosporis late ellipsoideis vel plerumque ellipsoideis, (18–)20–23(–25) × (26–)30–40(–45) μ; membrana 2–3(–3.5) μ crassa, echinulata, flavida vel aureo-brunnea; poris germinationis 3 vel 4, aequatorialibus, obscuris. Teliis hypophyllis, pulvinatis, 0.2–0.8 mm. diam., concentrice dispositis, ceraceis, compactis, brunneis; teliosporis plerumque oblongis, 10–14 × 25–45 μ; membrana hyalina, 0.5 μ crassa; pedicello persistenti, 8–12 × 25–45 μ, hyalino.

Type: On *Oncidium tetrapetalum* Willd., Pass-A-Grille, Fla., June 1959, comm. J. H. Bollick, Acc. 0–6628, State Plant Board of Florida (PUR).

This species has larger urediospores than *S. kevorkianii* Linder and *S. mera* Cumm. but the telia are similar, including the presence of abundant orange-colored oil in the sori.

The infected plants were supposedly imported from Jamaica in January or February, 1959.

Uraecium leonense sp. nov. Spermagoniis epiphyllis, subcuticularibus vel plus minusve intraepidermalibus, lenticularibus, 45–65 μ altis, 100–140 μ latis, sine paraphysibus. Aeciis hypophyllis, plerumque circinatim dispositis, brunneis, 0.1–0.15 mm. diam., uredinoideis; aeciosporis asymmetricis, ellipsoideis vel triangularibus, (19–)21–24(–25) × (22–)24–27(–28) μ;

membrana 1–1.5 μ crassa, cinnamomeo-brunnea, echinulata; poris germinationis 2, juxta hilum dispositis.

Type: On *Manilkara lacera* (Baker) Dubard, Kent (colony), Sierra Leone, May 17, 1951, *F. C. Deighton M4129A* (IMI, PUR).

The spore shape is ellipsoid when the pores are lateral but strongly triangular when the pores are in face-view, which is true of several species of the genus *Scopella* to which this fungus doubtless belongs. *S. sapotae* Mains ex Cumm. and *S. gentilis* Thirum. & Mundkur ex Cumm. have similar aeciospores but with thicker walls.

Uredo angusii sp. nov. (fig. 11). Urediis hypophyllis, erumpentibus, 0.2–0.6(–1.0) mm. diam., atro-brunneis; periphysibus brunneis, cylindraceis vel incurvatis, paucis; urediosporis ovatis, late ellipsoideis, vel triangularibus, (22–)24–27(–29) × (27–)29–34(–36) μ; membrana bilaminata, lamina interiori 3–4 μ crassa, castaneo-brunnea, lamina exteriori 1–2 μ crassa, hyalina, echinulata; poris germinationis 3(vel 4), aequatorialibus.

Type: On *Stereospermum kunthianum* Cham., west Kafue river road bridge, N. Rhodesia, Aug. 25, 1957, *A. Angus M385* (IMI, PUR).

This fungus may belong to the genus *Phragmidiella;* it is similar to *P. markhamiae* P. Henn. and *P. africana* Cumm. The sorus also is similar to the uredia of the genus *Olivea*. Both genera tend to have triangular urediospores with 1 germ pore in each angle.

Uredo aureospora sp. nov. (fig. 8). Urediis hypophyllis, minutis, sparsis vel aggregatis, flavidis, per stomata erumpentibus; urediosporis asymmetricis, reniformibus, 13–21 μ latis, 26–30 μ longis; membrana 1.5–2 μ crassa, hyalina, verrucosa vel verrucoso-echinulata; poris germinationis obscuris.

Type: On *Sabicea discolor* Stapf, Kumasi, Ghana, Feb. 2, 1956, *L. Piening CB2356* (IMI, PUR); Feb. 24, 1956, *Piening CB2267*.

This fungus undoubtedly is a *Hemileia* and has sori of the "superstomatal A" type of Gopalkrishnan (Mycologia **43**: 217–283. 1951). The typically "hump-backed" spores are verrucose on the convex side, except at the ends which are nearly aculeate, and smooth on the concave side. The hilum is centrally located on the convex side. As spore production continues, the sporogenous cells elongate to reach at least 100 μ and appear as fringed columns protruding from the tomentum of the leaf.

Uredo corchori (Syd.) comb. nov. *Cerotelium corchori* Syd Ann. Mycol. **36**: 15. 1938). Telia are not known.

Uredo dombeyicola sp. nov. Urediis hypophyllis, sparsis, poro centrali apertis, 90–140 μ diam.; periphysibus copiosis, hyalinis, cylindraceis vel curvatis, 10–16 μ latis, usque 55 μ longis; membrana 1–1.5 μ crassa, ad apicem 2–6 μ crassa; urediosporis fere sessilibus, plerumque ellipsoideis, (15–)17–21(–23) × (25–)28–33(–37) μ; membrana 1.5–2 μ crassa, hyalina vel flavidula, echinulata; poris germinationis obscuris.

Type: On *Dombeya buettneri* K. Schum., Behwai near Kumasi, Ghana, Jan. 30, 1956, *L. Piening CB2233* p. p. (IMI, PUR).

The structure of the uredia indicates that this fungus belongs in *Phakopsora* or *Physopella. Phakopsora byttneriae* Cumm. & Joerst., the only

species of *Phakopsora* recorded on the Sterculiaceae, has urediospores 23 μ or less in length. A specimen on *Dombeya* sp., collected at Beau Bassin, Mauritius, July 17, 1959 by Felix (No. D416), has urediospores most of which are 16–18 × 23–29 μ, thus intermediate between *P. byttneria* and *U. dombeyicola*. I am inclined to consider the Felix specimen as a variant of *U. dombeyicola*.

Uredo deightonii (Syd.) comb. nov. (*Hemileia deightonii* Syd. Ann. Mycol. **35**: 247. 1937). Telia are not known.

UREDO ENTANDROPHRAGMAE Cumm. The host has been identified by Mr. P. Taylor at Kew as *Lannea welwitschii* (Hiern) Engl. of the Anacardiaceae and not *Entandrophragma* of the Meliaceae. *Uredo aburiensis* Cumm. (Bull. Torrey Bot. Club **79**: 229. 1952) on *Lannea acidissima* A. Chev. is synonymous.

Uredo fleuryae sp. nov. Soris hypophyllis, sparsis vel laxe aggregatis, flavidis, usque 150 μ diam., peridio tenui circumdatis, poro centrali apertis; urediosporis ellipsoideis vel obovoideis, (15–)16–18 × (22–)24–28(–30) μ; membrana hyalina vel flavo-brunnea, 1 μ crassa, minuteque echinulata; poris germinationis obscuris, verisimiliter aequatorialibus.

Type: On *Fleurya interrupta* Gaud., Epo Agricultural Experiment Station, New Guinea, Apr. 6, 1959, *D. Shaw 2296* (IMI, PUR).

Uredo harunganae (Cumm.) comb. nov. (*Hemileia harunganae* Cumm. Bull. Torrey Bot. Club **70**: 522. 1943). Telia are not known.

Uredo kumasensis sp. nov. Soris hypophyllis, minutis, aggregatis, pallide flavidis, per stomata erumpentibus; urediosporis late ellipsoideis vel plus minusve lateraliter asymmetricis, 17–20 × 21–25 μ; membrana 1.5–2 μ crassa, hyalina, echinulata; poris germinationis obscuris.

Type: On *Sabicea* (? *geophiloides* Wernham), Kumasi, Ghana, Apr. 16, 1956, *L. Piening CB2345* (IMI, PUR).

This fungus, undoubtedly a *Hemileia*, has sori of the "superstomatal B" type of Gopalkrishnan (Mycologia **43**: 271–283. 1951). The spores are only slightly unilaterally flattened and the hilum is basal with reference to the long axis.

Uredo oxyanthi (Cumm.) comb. nov. (*Hemileia oxyanthi* Cumm. Bull. Torrey Bot. Club **68**: 467. 1941). Telia are not known.

Uredo phyllanthina (Syd.) comb. nov. *Coleosporium phyllanthinum* Syd. Ann. Mycol. **35**: 256, 1937). Telia are not known.

Uredo pieningii sp. nov. (fig. 6). Soris amphigenis, pulverulentis, flavidis, 0.1–0.4 mm. diam., sparsis vel circinatim dispositis; urediosporis late ellipsoideis vel globoideis, 23–27 × 25–29(–31) μ; membrana 3.5–4 μ crassa, pallide flavida, echinulata; poris germinationis non visis.

Type: On *Polyspatha paniculata* Benth., Kumasi, Ghana, Jan. 23, 1956, *L. Piening CB2226* (IMI, PUR).

No other rust fungus on Commelinaceae has such thick-walled urediospores except *Uromyces pretoriensis* Doidge and its spores are dark brown. Rust fungi have not been reported previously on *Polyspatha*.

Uredo rutideae (Cumm.) comb. nov. (*Hemileia rutideae* Cumm. Bull.

Torrey Bot. Club. **70**: 522. 1943). Telia are not known. The host is *Canthium scabrum* Bullock rather than *Rutidea rufipilis* Hiern, but the fungus differs from *Hemileia canthii* Berk. & Br.

Uredo scitula (Syd.) comb. nov. (*Hemileia scitula* Syd. Ann. Mycol. **35**: 247. 1937). Telia are not known.

Uredo tillandsiae sp. nov. (fig. 5). Soris hypophyllis, pulverulentis, flavo-brunneis, sparsis vel laxe aggregatis, rotundatis vel ellipticis, 0.2–0.5 mm. longis, epidermide rupta cinctis; urediosporis plerumque ellipsoideis, (22–)24–30(–33) × (34–)38–52(–55) μ; membrana pallide flavida vel aureo-brunnea, prominenter echinulata, 3–4 μ crassa; poris germinationis aequatorialibus, obscuris, verisimiliter 4.

Type: On *Tillandsia* sp., Mexico (intercepted in customs, Miami, Fla., Apr. 17, 1957, Inspector A. S. Mills, Miami No. 4519 (BPI, PUR); June 13, 1958, Inspector H. L. Rubin, Miami No. 6454).

This fungus has much larger spores than *Uredo nidularii* P. Henn. described from Brasil. The spines on the spores of *U. tillandsiae* are 2–3.5 μ long and 4–6 μ apart.

Uredo trichomoides sp. nov. Soris hypophyllis, in maculis laxe dispositis, ochraceo-fulvis, erumpentibus, 0.1–0.4 mm. diam.; periphysibus copiosis, cylindraceis, tortuositer incurvatis, 8–15 μ latis, usque 350 μ longis; membrana hyalina vel aurea, parte dorsali 4–8 μ crassa, ventrali 1–3 μ crassa; urediosporis plerumque late ellipsoideis vel globoideis, 17–20 × 20–25 μ; membrana hyalina vel pallide aurea, echinulata, (2–)2.5(–3) μ crassa; poris germinationis obscuris.

Type: On *Leptoderris brachyptera* (Benth.) Dunn, Njala (Kori), Sierra Leone, Feb. 16, 1953, *F. C. Deighton M5125-C* (IMI, PUR).

The species is distinctive because of the long, tortuously curved paraphyses. The sori have a narrow base but expand to a basket-like form above the epidermis.

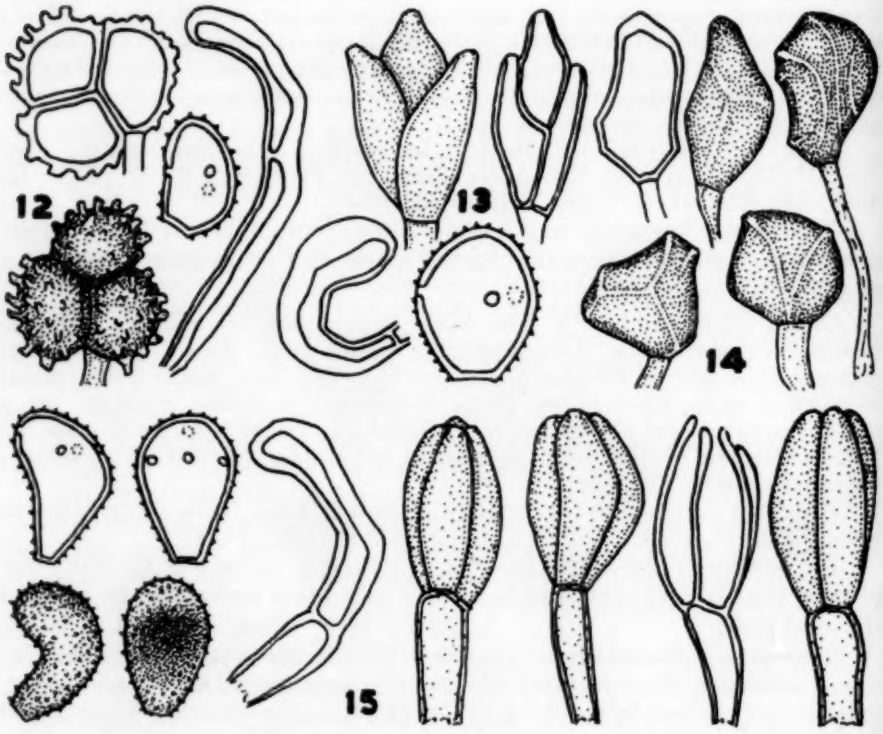
Uromyces bufforestiae sp. nov. (fig. 10). Urediis hypophyllis, erumpentibus, pulvinatis, flavo-brunneis, in maculis aggregatis; urediosporis plerumque late ellipsoideis, 19–21 × (23–)24–28 μ; membrana hyalina vel flavida, (1.5–)2(–3) μ crassa, echinulata; poris germinationis 2, aequatorialibus, obscuris. Teliis conformibus sed compactis, cinnamomeo-brunneis; teliosporis ellipsoideis vel oblongo-ellipsoideis, rarius ovoideis, (12–)13–16(–18) × (21–)23–30(–33) μ; membrana 1.5 μ crassa, ad apicem (2–)3–5(–6) μ crassa, pallide aureo-brunnea, levi; pedicello hyalino, tenui, persistenti, usque 50 μ longo.

Type: On *Buforrestia imperforata* C. B. Clark, Kumasi, Ghana, Apr. 4, 1956, *L. Piening CB2311* (IMI, PUR).

This is the first rust fungus reported on *Buforrestia*. Of the 4 species of *Uromyces* on the Commelinaceae, *U. commelinae* Cke. and *U. laevigatus* Syd. have dark brown urediospores and teliospores, *U. pretoriensis* Doidge has brown urediospores and pale but longer teliospores, and *U. cyanotidis* Cumm. has brown urediospores and pale teliospores whose apical wall is 8–18 μ thick.

Uromyces loculatus sp. nov. (fig. 14). Urediis hypophyllis, in maculis aggregatis, subepidermalibus dein longitudinaliter dehiscentibus, ellipticis,

usque 0.4 mm. longis; urediosporis ellipsoideis vel ovoideis, (15–)17–20 (–22) × (22–)24–29(–31) μ; membrana hyalina vel pallide flavida, 1–1.5 μ crassa, echinulata; poris germinationis obscuris. Teliis subepidermalibus, indehiscentibus, paraphysibus coalitis praeditis, loculatis, loculis 75–115 μ diam.; teliosporis variabilibus, angulariter ellipsoideis, obovoideis, oblongis,



FIGS. 12–15. FIG. 12. Two teliospores, one urediospore, and a paraphysis of *Hapalophragmium ornatum* Cumm. FIG. 13. Two teliospores, a paraphysis, and one urediospore of *Hapalophragmium pieningii* Cumm. FIG. 14. Five teliospores of *Uromyces loculatus* Cumm. FIG. 15. Four urediospores, a paraphysis, and four teliospores of *Diorchidium tetrasporum* Cumm. Camera lucida drawings from types. × 800.

vel globoideis, (14–)16–19(–20) × (17–)22–29(–31) μ; membrana 1–1.5 μ crassa, ad apicem (2–)3–4(–5) μ crassa, castaneo-brunnea, pedicello persistenti, hyalino, tenui, usque 70 μ longo.

Type: On *Kyllinga* sp., 12 miles north of Choma, N. Rhodesia, Mar. 17, 1956, *E. A. Robinson 1371* (K, PUR).

One other species, *U. notabilis* Wakef. & Hansf., occurs on *Kyllinga* but it has teliospores 30–45 μ long. Only a few of the species on Cyperaceae, e. g. *U. americanus* Speg. on *Scripus*, *U. bermudianus* Cumm. on *Cyperus*, and perhaps *U. notabilis*, have loculate telia. *U. loculatus* is the first species

that has the features of Guyot's (Encyc. Mycol. **8**: 26. 1938) section *angulati-Uromyces*.

Uromyces pieningii sp. nov. (fig. 9). Spermagoniis non visis. Aeciis hypophyllis, laxe aggregatis, cylindraceis, 0.2–0.3 mm. diam., margine lacerato; cellulis peridii hyalinis, oblongo-ellipsoideis, 15–23 × 30–40 μ; pariete interiori rugoso 3 μ crasso, exteriori striato 3–4 μ crasso; aeciosporis ellipsoideis vel globoideis, 15–20 × 23–27 μ; membrana 1 μ crassa, hyalina, verrucosa. Urediis non visis. Teliis hypophyllis, sparsis, atris, pulverulentis, rotundatis, usque 0.5 μ diam.; teliosporis plerumque oblato-sphaeroideis, 30–35 μ latis, 25–30 μ altis; membrana 3.5–4.5 μ crassa, castaneo-brunnea, minuteque longitudinaliter verrucoso-striata vel recticulato-striata; pedicello hyalino vel flavido, usque 65 μ longo, caduco.

Type: On *Ipomoea argentaurea* Hall. f., Nyankpala near Tamale, N. Territories, Ghana, May 12, 1956, *L. Piening CB2373* (IMI, PUR).

This fungus differs from *U. ipomoeae* Berk. in having terete pedicels and much less distinct striations, and from *U. greenstockii* Diodge because the teliospores of the latter are not striated, or oblate-sphaeroid, or nearly so deeply pigmented.

The pedicel of the teliospore of *U. pieningii* has a sort of collar at the hilum below which there is a terete and refractive part subtended by a thin-walled part. Breakage occurs at the base of the terete segment. The germ pore is apical and covered by a golden discoid umbo about 2 μ high but this is seen only when the spore is precisely oriented.

Zaghouania oleae (Butl.) comb. nov. (*Cystopsora oleae* Butl. Ann. Mycol. **8**: 448. 1910).

I have recently (Illustrated Genera of Rust Fungi. 131 pp. Burgess Publ. Co. 1959) treated the genus *Cystopsora* Butl. as a synonym of *Zaghouania* but the type species was not transferred.

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FOREST-PRAIRIE TRANSITION WEST OF ITASCA PARK, MINNESOTA

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The transition from forest to prairie west of Itasca Park, Minnesota, is remarkably abrupt. For one traveling west on the highway (state route 113) the change is dramatic, since the margin of the forest coincides rather closely with the crest of the high Big Stone moraine that runs north and south at this point (Leverett and Sardeson 1932). When one reaches the high point on the road after traveling west through hilly, forested country, a completely new landscape suddenly appears which is open and dotted with prosperous farms. A very large proportion of the land is farmed, and about the homesteads trees have been planted. These, added to scattered natural thickets of trees and brush, result in a patch-work of vegetation. Nearly all of the original vegetation has been destroyed; the land has been plowed and is now generally planted to crops such as grain, soya beans or flax. There are, however, a number of prairie relicts which are either pastured or, more often, cut for hay, and a few of these are not at present used in either way. The soil is rather uniformly a prairie soil with its black A horizon. Upham's (1884) map of the vegetation published about sixteen years before the first white man settled in the country east of Waubun shows the line between forest and prairie passing through that area.

The present study was made across the southern parts of Mahnomen County and adjacent Norman County. A variety of physiographic features are thus included. At the east is high morainic country. Generally well-drained land slopes from the moraine west to the town of Waubun. Immediately west of Waubun the topography, developed on ground moraine, is low and rolling and the drainage is poor. As the western edge of Mahnomen County is approached the land rises again to the low but well-drained Erskine moraine whose crest is in Norman County. Beyond, to the west of the Erskine moraine are swales and low ridges along the margin of glacial Lake Agassiz (Leverett and Sardeson 1932).

Upon this varying topography westward from the top of the Big Stone moraine are a number of scattered relicts of native vegetation in the matrix of cultivated farm land. They reflect in part the early historical influences on the vegetation and in part the changes induced by settlement and agricultural use of the land. The objectives of this present study have been (1) to discover the present vegetational features of this transition area and (2) to describe as far as possible its characteristics at the time of settlement and (3) to discuss the environmental influences that have effected both.

In a study made farther north Ewing (1924) described what he referred to as the "brush prairie". He found that native prairie was being encroached upon by spreading thickets of shrubs and trees, especially aspen. This he ascribed to descreased frequency of prairie fires.

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Methods. A transect one mile wide and 22 miles long extending from the top of the Big Stone moraine in Mahnomen County west to Syre in Norman County was selected for study. The transect had its southern boundary along Minnesota State highway 113. The easternmost end of the transect was along the east boundary of section 19, T143N R40W and the westernmost end coincided with the western boundary of section 22 T143N R44W. On the Big Stone moraine section 18, just north of the transect, was included in the detailed study since the westernmost stand of sugar maple-basswood at this immediate latitude occurs within it (Buell and Cantlon 1951). Some study was also devoted to certain other locations near the transect strip which appeared to have vegetation that would yield valuable information in the interpretation of the transect.

All roads within the area were traveled by car; exploration was made on foot within the sections where it appeared that prairie relicts might be found. Aerial photographs were available for most of the area and were quite useful in this survey. Some of the larger blocks were entirely crossed by traverses on foot. Thus all of natural vegetation as far as could be determined was examined in some detail. A map was constructed from aerial photos. Stereoscopic examination of photo pairs complemented the data collected by the field survey.

Several of the older residents of the area were interviewed. These were all men who had come to the area before the railroad was constructed and before the White Earth Indian Reservation was opened up for settlement by white man.

Results. The natural vegetation occurring on the transect may be classified into eight categories as follows: 1. Maple-basswood forest; 2. oak and oak-aspen groves; 3. aspen stands; 4. shrub communities; 5. marshland; 6. dry prairie; 7. mesic prairie; 8. wet prairie.

Maple-basswood forest—The maple-basswood (*Acer saccharum—Tilia americana*) forest in the area of this study has already been described in detail (Buell and Cantlon 1951).

Oak and oak-aspen groves—Groves of oak, predominantly bur oak (*Quercus macrocarpa*) but frequently with pin oak (*Q. ellipsoidalis*), occur but are less characteristic than where aspen (*Populus tremuloides*) is present in mixture with the oaks. The oaks are characteristically low with spread-

ing branches. Where the groves are not grazed the shrub growth is dense under the trees, and on the periphery of the groves the shrub growth is especially thick. Conspicuous among the shrubs are *Cornus racemosa, Corylus americana, C. cornuta, Prunus virginiana, Ribes americanum, Rhus glabra, Rubus idaeus* var. *strigosus, Symphoricarpos occidentalis* and *Viburnum lentago. Celastrus scandens* and *Rhus radicans* are also usually present. Herbs are abundant, and conspicuous among them are *Actaea rubra, Agastache foeniculum, Anemone canadensis, Aralia nudicaulis, Caulophyllum thalictroides, Maianthemum canadense, Osmorrhiza longistylis, Phryma leptostachya, Rudbeckia laciniata, Sanicula marilandica, Smilacina racemosa, S. stellata, Solidago flexicaulis, Lysimachia ciliata, Thalictrum dasycarpum* and *T. dioicum.*

Aspen stands—Aspen forms stands without oak. This happens characteristically on lower ground—the stands originating around swales and spreading from there into surrounding grassland. The dense shrub border characteristic of the oak-aspen groves of higher ground is commonly replaced by a border of aspen root sprouts. Where unimpeded spread of the aspen occurs, the stands assume smooth dome-shaped profiles as successively younger aspen shoots arise from roots which may extend for considerable distance out into the sod (Buell and Buell 1959). Elsewhere they appear as vertical-sided clumps. Light penetrates the aspen canopy readily, and as a result the vegetation in the interior consists of a well-developed growth of shrubs and herbs. When the aspen thicket surrounds a depression, willows (Salix) and bog birch (*Betula pumila* var. *glandulifera*) are common at the center. In the rest of the stand the presence and relative abundance of different shrubs and herbs depends on the site, but in general the same species contribute as noted above for the oak-aspen groves.

Shrub communities—Ewing (1924) described shrub communities of upland areas which also can be found on the transect studied here. Several species are usually present but these shrub communities most often are predominantly of *Corylus americana* and *Rhus glabra* on the one hand or *Symphoricarpos occidentalis* on the other hand. The former is typically a fringe community associated with oak or oak-aspen groves. The latter, Symphoricarpos, forms extensive low-spreading colonies in pasture or dry grassland.

Marshland—In places marshes are rather extensive. Sedges and cattails as well as several grasses are predominant. Willows often grow at their margins.

The prairies. Three types of prairie are recognized in this study, all of them having a good number of species in common. For example, the grasses —*Andropogon scoparius* and *Koeleria cristata* together with certain forbs, *Amorpha canescens, Psoralea esculenta, Petalostemum purpureum* and *P.*

candidum—as well as others occur in all of them. There are, however, certain distinctive features of each of the three types. The descriptive terms used, wet, mesic, and dry, are terms that place the three types in relation to each other.

The dry prairie—The term dry prairie is used here to refer to a type of grassland that occurs on dry, sandy, exposed sites. Along with taller grasses, there is an abundance of *Bouteloua hirsuta* and *B. gracilis*. *Stipa comata* is prominent. Certain forbs—for example *Anemone patens* var. *wolfgangiana*, *Echinacea angustifolia*, and *Geum triflorum*—are more abundant than elsewhere.

The mesic prairie—The mesic prairie here refers to the prairies which occur on well-drained, but not coarse, soils on hills and slopes along the transect. Here the short grasses are sparse or absent, and *Stipa spartea* instead of *S. comata* is an important component of the vegetation.

The wet prairie—The wet prairie refers to the grasslands which are developed here on low ground where the water table is near the surface. *Bouteloua hirsuta* and *B. gracilis* are absent. The scattered occurrence of *Parnassia glauca*, *Lathyrus palustris*, and *Triglochin maritima* are indicative of site conditions distinct from the mesic prairies. Also *Zigadenus elegans* is most abundant in the wet prairie.

The survey of the mile-wide transect showed a relationship between these vegetation types and the various physiographic features of the area. To illustrate this and to reconstruct the probable distribution of the vegetation at the time of settlement by white man a topographic profile through the entire length of the transect was constructed. The presumed original distribution of the vegetation was diagrammed upon it (fig. 1). Elevation data were kindly furnished by the Detroit Lakes office of the Minnesota Department of Highways. Certain elevations off the highway were determined approximately by the use of the abney level.

The maple-basswood forest occupies the extreme eastern end of the transect. The eastern limit of the transect was chosen deliberately to include the westernmost stand of maple-basswood at this immediate latitude. The margin of this forest is remarkably abrupt here. In places it reaches the White Earth River. In places there is no such natural boundary. Within the mile to the west of the forest there is considerable land that is farmed, there is some prairie, considerable brushy land and scattered oak and oak-aspen groves. The prairie stand nearest to the maple-basswood forest is a small area of mesic prairie in NE S24 R41W. From this place west to Waubun there are only seven remaining areas of prairie that appear not to have been plowed and only two of these are mesic prairie. Wet prairie is more apt to have been preserved because of its wetness especially where drainage has been impracticable. The two mesic prairies, one small but very good example

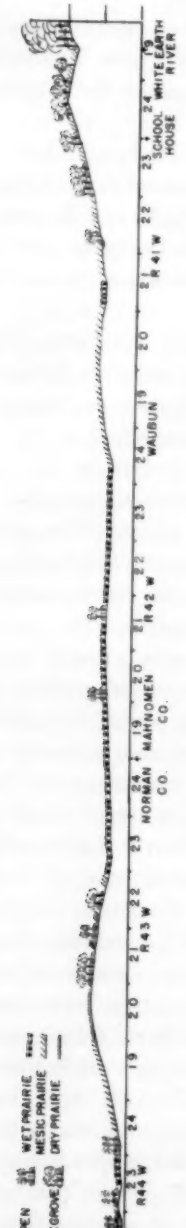

FIG. 1. Diagrammatic profile across the area of study. The western limit of the deciduous forest is shown at the eastern limit of the area (right hand end of the diagram). Other vegetation types are shown by the legend. Numbers at the bottom show sections in the range as indicated. All are in township 143 north. Altitudes in feet above sea level are shown by numbers at the extreme left. Elevations were made available by the State of Minnesota, Department of Highways, Detroit Lakes Office. The vegetation shown is reconstructed from notes on relict stands.

in the southwest corner of section 14 R41W and the other on the south side of the highway from section 22, are on rough, hilly land. The latter is pastured. *Stipa spartea* is prominent and several other prairie grasses are abundant—*Andropogon scoparius* and *A. gerardi*, and *Koeleria cristata*. *Bouteloua curtipendula* is present and *B. gracilis* occurs but not in such amounts as in the dry prairie. Twenty two species of characteristic prairie forbs were listed from this site. The land is not only rough but there are many large boulders which undoubtedly further discouraged cultivation. The top 8″ to 2′ of soil where examined contained no stones, suggesting possible aeolian origin. Stones below this layer had lime encrusted on them. Soil samples collected on a hill top and in a saddle betwen two hills showed a size-particle composition illustrated in table 1.

TABLE 1. *Mechanical analyses of soil samples collected from mesic prairie on the Big Stone moraine. (A) soil from saddle between two small hills. (B) soil from adjacent hilltop.*

Location	Depth in inches	% sand	% silt	% clay
(A)	12	55	31	14
(A)	24	51	27	22
(B)	12	42	33	25

Most of the cultivated land in the five miles between the top of the Big Stone moraine and Waubun is well-drained and very likely supported the same or very similar prairie vegetation as these relict stands. There are exceptions. Poorly-drained areas in sections 20 and 21 probably had wet prairie, now represented by the two wet prairie relicts which are in these sections. Oak and oak-aspen groves are frequent on the slope down from the maple-basswood forest. Commonly, although not always they occupy north- or northeast-facing exposures.

West of Waubun for about seven miles the land is low, gently rolling and poorly drained. There is a good deal of marsh area particularly in section 23. In fact marshes or swales occur throughout this area. Small relict wet prairies are still preserved in irregular angles between marshes as in the northwest corner of section 22 and the adjacent part of section 21. At the time of this study, good relict prairie occurred in the southeast corner of section 20 and the northwest quarter of section 21, but the former has been plowed since the study started. Just one mile south of this is section 33, a large part of which the Minnesota Department of Conservation has purchased for preservation of the prairie and the prairie ponds and designated as the Waubun Prairie Research Area.

The wet prairies in this area contain low mounds, referred to as Mima mounds, built up about a foot above the prairie level probably by pocket

gophers. The soil of these mounds is disturbed by the animal activity so that a distinctive group of weedy species flourishes on them. Some species commonly occurring on the mounds are: *Elymus canadensis, Monarda fistulosa, Heliopsis helianthoides* var. *scabra, Symphoricarpos occidentalis, Tanacetum vulgare,* and *Thalictrum dasycarpum.* Surrounding the mounds are the characteristic grasses and forbs of the wet prairie.

It is through this area of wet prairies that the aspen stands occur commonly. In fact the township west of Waubun is named Popple Grove. It has somewhat the appearance of a parkland with islands of aspen surrounded by prairie. There is a strong tendency for the aspen to spread by roots into the prairie (Buell and Buell 1959) and unless mowing or fire keep them back the prairie is doomed. The wet prairie on the north side of section 21 had been mowed until 1957. In 1958 a vigorous growth of aspen shoots were coming up extending the aspen grove 15 to 20 meters into prairie. A prairie fire in November 1958 killed most of the small shoots.

A soil pit dug in wet prairie showed no stones in the black A horizon. This horizon was 14 inches thick. The whitish horizon below this had some stones in it. Samples taken at 6 inches and 16 inches had the size-particle distribution shown in table 2.

TABLE 2. *Mechanical analyses of soils from wet prairie west of Waubun.*

Depth in inches	% sand	% silt	% clay
6	60	23	17
16	47	23	30

About seven miles west of Waubun the land rises. The slopes of the Erskine moraine are well drained. One mesic prairie lies within the mile wide strip of the transect. This is in the northwest corner of section 20. Just north of section 19 are two excellent prairie relicts—one of dry prairie on the highest point of land known locally as Frenchman's Bluff (NW SES18 T143N R43W), and the other of mesic prairie on a lower slope with transition to a dry prairie up the slope (SW S18 T143N R43W). The former, Frenchman's Bluff, is pastured in the southern part. The pasture fence runs across the hilltop so that the northern part has not been grazed, at least recently, but has been mowed. The local residents do not recall that it has ever been plowed and because of the rugged topography of most of it, it probably has been at least in part reserved for grazing and a source of hay.

The soil on Frenchman's Bluff was sampled in two places. In both places the A horizon was a dark brown. Limestone pebbles were found within six

inches of the surface. The mechanical analysis shows the soil to be a sand (table 3).

TABLE 3. *Mechanical analyses of soils from the Erskine moraine.*

Location	Depth in inches	% sand	% silt	% clay
Dry Prairie top of moraine (Frenchman's Bluff) station 1.	8	85	11	4
Same as above	24	82	11	7
Same, Station 2	12	82	15	3
Mesic prairie, e. side of moraine, n.w. corner of section 20	11	96	2	2
Dry prairie, w. side of moraine, s.w. section 18	3	51	47	3
Same as above	12	78	15	7
Oak grove, n.w., s.w. section 20	4	57	29	14
Same as above	13	58	18	24

The soil was also examined in the mesic prairie in the northwest corner of section 20 on the east slope of the moraine. The A horizon was dark blackish-brown and about seven inches deep, and below this the soil was brown.

The mesic prairie west of Frenchman's Bluff in the southwest corner of section 18 is on a steep west-facing bank and extends upward to a level terrace-like top. Oak-aspen groves occupy cove-like depressions on either side and below the prairie. Probably because of its steepness, its gravelly soil and its small extent (being hemmed in by wooded groves), it has escaped cultivation although it has been a source of hay. The lower slope falls into the classification as mesic prairie but on the upper slope and the top *Stipa spartea* gives way to *S. comata*, and *Bouteloua gracilis* and *B. hirsuta* appear, the latter becoming abundant. A soil profile part way up the slope showed a blackish-brown A horizon only about four inches deep, below which the soil is dark brown. Stones are present to the surface (table 3).

There is also a considerable amount of wooded area on the Erskine moraine. Bur oak is especially abundant, but in most instances aspen is mixed in with the oaks and in some places the aspen predominates. The vegetation of these groves is typical of the oak and oak-aspen groves already described. Because of the striking contrast between the dry prairie and the mesic prairie on the one hand and the woodlands on the other, a soil profile was examined in the woodland and samples were taken for mechanical analysis. The A horizon is black to a depth of eight inches and there are no stones present. Below eight inches the soil is whitish and stones are present. One sample was taken at four inches and a second at about 13 inches (table 3).

The distribution of prairie vs. forest on the Erskine moraine may be related in large part to exposure, such as the hilltop and west-facing slope

combined with coarse soil. The prairie in the northwest corner of section 20 is on an east-facing slope but with the compensating feature of having the most extremely coarse soil of all of the sites studied. Woodland occupies the heavier soils.

Beyond the western slope of the Erskine moraine the three remaining sections, Nos. 24, 23, and 22, of the transect are low and there is a considerable amount of poorly-drained land. They are crossed by low, gently sloping beach ridges of glacial Lake Agassiz. According to a local resident, the beach ridge running north-south through section 23 was the location of the main road through this area in the early days of settlement, other places being too low and wet for travel. The beach ridges may have supported mesic prairie. Certainly most of this area did not. The only two prairie remnants that were located are stands of wet prairie, one among aspen groves (NW S23) and the other on a corner of land much of the time too wet for cultivation (SE S23). A third wet prairie remnant occurs just south of highway 113 (NE S25). Considerable areas of marshes and sloughs occur in low areas between the ridges. Willow thickets have grown up in some of these, and aspen stands have developed in places along their borders.

Recollections of certain older residents: Five of the older residents of this area were interviewed. Since the area through which the eastern part of the transect passes has been opened up for settlement since 1906, it was possible to get a fairly good idea of the pre-settlement conditions there. The following paragraphs give the results of interviews with older residents familiar with various areas crossed by the transect.

Just east of Syre there lives a farmer, Mr. H. E. Huseby, whose property in large part lies on a beach ridge of Lake Agassiz. According to him, his father settled on the beach ridge partly because it was so wet elsewhere. His house was located on the main north-south road that followed the ridge.

Mr. Kirkeby is a farmer who lives on highway 113 where it crosses the Erskine moraine (SW S20). This location was west of the White Earth Indian Reservation when his father came there from Iowa about 1884. He settled on this hill "after traveling for miles through water." Much of the low prairie over which he had been traveling was flooded and this was the first high, well-drained ground. According to him there was more grassland and less woodland in the early part of the century. The oak (*Quercus macrocarpa*) woods behind his house, now pastured, was primarily aspen (*Populus tremuloides*), but in time aspen has died and the oaks have grown.

Mr. Gunnerson has a meat market in Waubun. When he was a boy he traveled with his father who bought wares from the white settlements to sell to the Indians on the reservation. This was before 1900 when the Waubun area was a part of the White Earth Indian Reservation. He spoke of the wet prairies west of Waubun and of frequent prairie fires. He

said that before 1906 a few white men rented farms from the Indians on the Reservation but could not own them. In 1906 the Reservation was opened up to white settlement and then land could be sold to white men.

Mr. S. B. Olson of Mahnomen was one of the original inhabitants. Mahnomen, 10 miles directly north of Waubun, was established as a village in 1905, and the county was established in 1907. In 1905 the area north of Mahnomen was largely open prairie. The aspen groves, so common there now, have developed in recent years. There is much more woodland in the whole area now than in 1904. It is drier now. On Frenchman's Bluff there was scrub oak (referring probably to areas now in oak woodland).

According to Mr. Olson, before the reservation was opened up to white settlement the Indians lived along "the edge of the timber." The government established farms and persuaded the Indians to raise grain. They were paid $1 a bushel in addition to what they could get on the market but they didn't go into farming enthusiastically nor on a large scale. In 1905 it was open wet prairie between Mahnomen and Waubun. Because it was so wet, it was not put into farms until recently. In the early days prairie fires were frequent. The Indians set them. The fires could be seen coming especially from the southeast. Protection was by plowing a furrow and back-firing.

Mr. Carl Pederson was 19 years old in 1900 when he came to Lake Grove Township. He settled 3 miles east of Waubun on the Reservation. According to him white men married Indian women so they could farm land on the Reservation. There were no more woods there then than today. What there were were mainly on steep, east and north slopes. The Indians burned the prairie, usually setting fires in the spring when there were still snow banks on these wooded slopes. In the prairie east of Waubun the "prairie needles" (Stipa) was most abundant.

On June 9, 1955 at the occasion of the 50th anniversary of the town of Mahnomen, "The Mahnomen Pioneer" published a "Golden Jubilee Section" in which much of the history of the area was printed. Of especial interest is an article entitled "Indian chief recalls history of White Earth Indian Reservation—as told by Chief Little Cloud." According to this, 1955 marked the 50th anniversary of the opening of the reservation. Previous to the opening it was unsettled, virgin land. In 1904 the Soo Line R. R. completed its railroad through here. There were at that time no towns between Detroit Lakes and Erskine. Before the reservation was opened up there were very few allotments being farmed. "I recall two white men both having married woman of Indian blood, who were farming." A few full-blooded Indians farmed part of their allotments. He named eight near Waubun, the general area where he lived, and a number near Mahnomen, an area with which he was less familiar. The Clapp Amendment, passed in 1906, permitted any "mixed blood Indians to alienate their lands as soon as

they had selected their allotments." The land was thus opened up for purchase by white settlers.

Discussion. The distribution of vegetation along the topographic profile from the top of the Big Stone moraine west to Syre suggests that the physiography has a rather strong influence on the vegetation pattern. This is especially so where the distribution of soils is also considered. In the first place, the surface topography by influencing drainage determines the position of the low, wet prairies as distinct from the well-drained, mesic and dry prairies. The dry prairie occurs, as we have seen, where the deep, coarse, sandy soils occur in high and exposed sites. The oak and oak-aspen groves are favored by heavier soils or by topographic sites with the compensating factors of more favorable moisture balance and, in consequence, less liability to prairie fires.

Whether the western limit of deciduous forest lying as it does here along or near the summit of the Big Stone moraine has more than fortuitous relation to topography remains to be discovered. It very probably does where it stops at the White Earth River but this is only in certain places. Possibly the moraine is high enough to have an orographic effect on rainfall. Possibly also the drier exposure of the western slope of the moraine itself or this coupled with prairie fires may have served to limit the extension of forest farther west. Actually the forest margin has apparently recently stood even farther east. Both the soil and the character of the vegetation indicate this. Recent (somewhat over 100 years ago) establishment of forest on former prairie or more probably in brushland is suggested by a study in this area, an event that may possibly indicate a time of especially favorable conditions for forest (Buell and Cantlon 1951). Tree ring studies in North Dakota lend support to this idea (Will 1946).

The relation between the present character of the wet prairie and increased drainage of the land is probably rather close. In recent years drainage of the land has progressed rapidly along with modern road construction. It is the practice here to couple road building with excavation of large roadside ditches. These have increased greatly the drainage of the wet prairies. As a result, species that may have been limited to occasional drier spots or even that may have been absent have spread or have invaded. *Andropogon scoparius* may be an example of one that has spread. Others characteristic of wet places such as *Triglochin maritima* have undoubtedly decreased. Certainly the marshes have been greatly affected. However, the result has primarily been that many of the wet prairies previously too wet for cropping have been put into cultivation and only a few remnants are left. The reports of the wetness of the land and its unsuitability for farming in the early part of the century are in contrast to the almost complete use of wet prairie lands today.

The pressure of the spread of aspen on the surrounding prairie is a striking feature of the wet prairie areas. Prairie fires appear to be very effective in killing small aspen trees and in causing damage to older ones. It is probable that in the Indian days the frequent prairie fires were responsible for preventing the aspen from spreading over the wet prairies. Since white man has come into the picture, either mowing or occasional fire have served to hold the aspen back somewhat. However, reports by the older residents indicate that aspen has increased considerably in area since settlement by white man.

In conclusion, the forest-prairie boundary in Indian days was accentuated by prairie fires, the fires helping to maintain grassland often right up to the near vicinity of the abrupt deciduous forest border. Cultivation tends to keep the open aspect of the countryside, but evidences of the ability of the woodlands to increase at the expense of prairie are present. Were it not for man's influence, and in the absence of fire, the prairie area in primitive times would have been restricted to topographic and edaphic sites most favorable to it, and oak, oak-aspen, aspen, and possibly certain shrub communities would have occupied larger areas.

SUMMARY

1. The forest-prairie margin west of Itasca Park is remarkably abrupt. The western limit of deciduous forest coincides there with the top of the Big Stone moraine.

2. Westward, beyond this, the distribution of the various plant communities—oak and oak-aspen groves, aspen stands, shrub communities, marshes, wet prairie, mesic prairie, and dry prairie of mixed short and tall grasses—is related to totpography of the land together with the distribution of soils of different textures.

3. Woodland has increased and prairie has decreased in extent in the last half century.

4. Pronounced changes that have occurred in uncultivated areas are the result of decreased fire incidence throughout and drainage of the wetlands.

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TORREYA

Additions and Corrections to a Flora of Rockland County, New York.

J. HARRY LEHR

Further studies both in the herbarium and in the field have given the writer the opportunity to make the following additions and corrections to his "Annotated Preliminary Catalogue of the Vascular Flora of Rockland County, New York (See Bull. Torr. Club, **83**: 435–438, 1956; **84**: 48–56, 126–134, 206–213, 310–317, 388–392, 450–452, 1957; and **85**: 488–489, 1958." The abbreviations, the references, and the phylogeny of this supplement remain unchanged from the original catalogue.

EQUISETACEAE

*EQUISETUM ARVENSE L. var. BOREALE (Bong.) Ledeb. Field Horsetail. Ramapo. (H)

POLYPODIACEAE

ATHYRIUM FILIX-FEMINA (L.) Roth var. MICHAUXII (Spreng.) Farw. forma RUBELLUM (Gilbert) Farw. Lady-Fern. Ramapo. (H)

GRAMINEAE

*BROMUS COMMUTATUS Schrad. Smooth Brome Grass. Clarkestown. (H)

BROMUS TECTORUM L. Downy Brome Glass. Clarkestown. (H)

*ELYMUS RIPARIUS Wieg. Riverbank Rye. Ramapo, Orangetown. (H)

CYPERACEAE

*SCIRPUS VERECUNDUS Fern. Wood Club Rush. Orangetown. (H)

CAREX GRACILESCENS Steud. Slender Loose-flowered Sedge. Ramapo, Orangetown. (H)

ARACEAE

ARISAEMA ATRORUBENS (Ait). Blume forma ZEBRINUM (Sims) Fern. Jack-in-the-Pulpit. Ramapo. (H)

ARISAEMA ATRORUBENS (Ait.) Blume forma VIRIDE (Engler) Fern. Jack-in-the-Pulpit. Ramapo. (H)

COMMELINACEAE

*TRADESCANTIA OHIENSIS Raf. Glaucous Spiderwort. Ramapo. (H)

JUNCACEAE

*JUNCUS SUBCAUDATUS (Engelm.) Coville & Blake. Short-tailed Rush. Ramapo. (H)

LILIACEAE

*ALLIUM TRICOCCUM Ait., var. BURDICKII, Hanes, (Rhod. 55: 243–244, 1953). No reference is made in either of the two basic manuals of the range to this variation in leaf outline, petiole color or sheath color. The write has studied both the species and the variety thoroughly in Ramapo Township and he doubts var. BURDICKII's status as an ecological variant. Here, in this township, both the species and the variety frequently grow together, in almost every instance, on the border of wooded swamps. Ramapo. (H)

*TRILLIUM CERNUUM L. var. MACRANTHUM Wieg. Large-flowered Nodding Trillium. Ramapo. (H)

CORYLACEAE

ALNUS SERRULATA (Ait.) Willd. Hazel Alder. Stony Point. (H)

ULMACEAE

ULMUS AMERICANA L. forma PENDULA (Ait.) Fern. American Elm. Ramapo. (H)

POLYGONACEAE

TOVARA VIRGINIANA (L.) Raf. forma RUBRA Moldenke. Jumpseed. Ramapo. (H)

AMARANTHACEAE

*AMARANTHUS ALBUS L. Tumbleweed. Clarkestown. (H)

CRUCIFERAE

*BARBAREA VULGARIS R. Br. var. ARCUATA (Opiz) Fries. In this county, this variety with spreading siliques is more common than the species with its appressed or erect siliques. Ramapo. (H)

SAXIFRAGACEAE

*RIBES ROTUNDIFOLIUM Michx. Round-leaved Gooseberry. Stony Point. (H)

ROSACEAE

PRUNUS VIRGINIANA L. Choke-Cherry. Clarkestown. (H)

LEGUMINOSAE

*VICIA ANGUSTIFOLIA Reichard var. SEGETALIS (Thuill.) W. D. J. Koch. Narrow-leaved Vetch. Ramapo. (H)

POLYGALACEAE

POLYGALA VERTICILLATA L. var. ISOCYCLA Fern. Whorled Milk-wort. Stony Point. (H)

UMBELLIFERAE

LILAEOPSIS CHINENSIS (L). Ktze. Lilaeopsis. Orangetown. (H)

CORNACEAE

CORNUS FLORIDA L. Many shades of pink in the flower color of this tree have been observed throughout the county, but none are deep enough to warrant their designation as forma RUBRA (red). The color of our deepest specimen approximated Ridgeway's "La France" pink.

APOCYNACEAE

APOCYNUM SIBIRICUM Jacq. var. CORDIGERUM (Greene) Fern. Indian Hemp. Orangetown. (H)

BORAGINACEAE

*SYMPHYTUM ASPERUM Lepechin. Prickly Comfrey. Ramapo. (H)

CAPRIFOLIACEAE

*LONICERA XYLOSTEUM L. European Fly Honeysuckle. Ramapo. (H)

CAMPANULACEAE

*CAMPANULA ULIGINOSA Ryd. Blue Marsh Bellflower. Clarkestown. (H). The author agrees with Hanes (Flora of Kalamazoo County) relative to the confusion in the two basic manuals of the range concerning this species and *C. aparinoides*. There is at present, to the knowledge of the writer, but one station in the county for this species. In a series

of collections made at this station the following observations were made. Peduncles were about equally divided between ascending or divergent and about the same average was observed in peduncles being leafy-bracted or naked. The naked summits ranged from 1.2 to 3.8 cm. long and the corollas from 9 mm. to 10 mm. long. All of the material was bluish-flowered and this factor greatly influenced the final determination of the writer.

COMPOSITAE

*Solidago juncea Ait. forma ramosa (Porter & Britton) Fern. Ramapo. (H)

Antennaria fallax Greene. Deceitful Cat's Foot. Clarkestown. (H)

A. neglecta Greene. Field Cat's Foot. Clarkestown. (H)

A. neodioica Greene. Smaller Cat's Foot. Ramapo. (H)

A. neodioica Greene var. attenuata Fern. Long-leaved Cat's Foot. Ramapo. (H)

A. plantaginifolia (L.) Hook. Ladies'-Tobacco. Stony Point. (H)

A. plantaginifolia (L.) Hook. var. petiolata (Fern.) Heller. Ladies'-Tobacco. Orangetown. (H)

Sonchus arvensis L. Perennial Sow Thistle. Orangetown. (H)

Spring Valley, New York

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Field Trips

May 9, 1959. Margaretville, Delaware County, New York. Twenty-seven people took to the hills for the joint meeting of the Torrey Botanical Club and the Eastern New York Botanical Club at Margaretville. The group first met at the home of Robert Van Benschoten, a local naturalist, for a cup of coffee, introductions, and a chance to chat before starting for the field. The Albany group was under the leadership of Stanley Smith, chairman of the ENYBC Field Committee.

Margaretville is located on the east branch of the Delaware River in the Town (township) of Middletown. The trip was scheduled to provide an opportunity to see and collect *Adoxa* as well as to make additions to the Delaware County flora. In order to facilitate field observations, the leader provided typewritten copies of a list of the plants collected and/or observed in the Town of Middletown in the hope not only that the list might be extended but also that some of the additions might be new county records.

The area visited was the north-facing slope of Pakatakan Mountain immediately south of Margaretville, ranging in elevation from 1400 feet at the base to over 3000 feet at the top. Most of the group, however, explored the area below 2400 feet. In early May this region exhibits the more or less typical spring flora of the beech-birch-maple woods. *Amelanchier arborea* and *A. laevis* were in bloom along the roadsides, and *Aquilegia canadensis canadensis* and *Anemone nemorosa americana* (*A. quinquefolia*) were blossoming at the edge of the woods. On the mountainside *Claytonia caroliniana* was everywhere in evidence. Other plants in blossom included scattered patches of *Asarum canadense canadense, Caulophyllum thalictroides,* both *Dicentra canadensis* and *D. cucullaria, Sanguinaria canadensis canadensis, Mitella diphylla, Viola eriocarpa, V. pubescens, V. rotundifolia, Luzula carolinae* S. Wats. (*L. acuminata*), *Erythronium americanum, Trillium erectum erectum,* and *Uvularia sessilifolia.* Already it was too late to find flowers of *Hepatica acutiloba.* Among the typical beech-birch-maple spring flora not yet in bloom, but plants of which were clearly evident, were *Thalictrum dioicum, Tiarella cordifolia cordifolia, Acer pensylvanicum, Hydrophyllum virginianum, Mitchella repens, Arisaema triphyllum triphyllum, Allium tricoccum, Maianthemum canadense canadense,* and *Polygonatum pubescens.* Typical ferns and fern allies observed included *Lycopodium lucidulum, Botrychium virginianum virginianum, Adiantum pedatum pedatum, Cystopteris fragilis mackayii, Dryopteris marginalis, Polypodium virginianum,* and *Polystichum acrostichoides.*

Among the plants growing in this area, however, were a number which are not typical of beech-birch-maple woods. *Asplenium rhizophyllum* (*Camptosorus rhizophyllus*), for example, while more common in the Catskills than one might think, is not typically associated with the beech-birch-maple flora, nor is *A. trichomanes*, both of which were observed at Margaretville. There is no limestone in the Catskill mountain area, but there is evidence that some of the Catskill shales and sandstones contain considerable amounts of lime. Henry Dunbar, of Kingston, tested the soil of two different colonies of *Asplenium rhizophyllum* and obtained readings of pH 5.6 and 6.2, respectively. *Cystopteris bulbifera*, which also seems to prefer calcareous soils, was likewise observed. Another atypical element noted was *Saxifraga virgiensis*, which was in full bloom.

Among the more unusual and rare plants seen in the Margaretville area on this trip, aside from *Adoxa*, was *Viola selkirkii*, a plant of shaded ravines and cool mountain slopes, and *Carex peckii*. Of the latter, House (1924) gave the distribution as "infrequent across the northern part of the State, southward to the Helderberg mountains of Albany county and westward to Monroe county" (p. 175). Two stations have now been located in Delaware County.

Efforts to extend the list of plants growing in Delaware County met with disappointment, but a number of plants not hitherto reported from the Town of Middletown (and not mentioned above) were located: *Berberis thunbergii*, *Ribes triste*, *Viola conspersa*, *V. incognita*, *V. rostrata*, *V. septentrionalis*, *Cornus alternifolia*, *Carex artitecta* (*C. nigro-marginata* var. *muhlenbergii*), *C. plantaginea*, and *Streptopus roseus roseus*. All these plants are more or less common in the Catskills and all have previously been reported from Delaware County.

Unusual or interesting plants which have been collected in the Town of Middletown on earlier trips include **Carya* x*Laneyi*, **Rorippa sylvestris*, *Sarracenia purpurea purpurea*, *Floerkea proserpinacoides*, **Acer negundo*, **Panax quinquefolius* *Gaultheria hispidula*, *Hydrophyllum canadense*, **Myosotis arvensis*, **Tussilago farfara*, and *Calla palustris*. Items preceded by an asterisk (*) have not previously been reported in the literature for Delaware County. The *Floerkea* was collected near the river and there is a suspicion that it may have been washed down from somewhere upstream, but there are areas in the county where it is locally abundant.

August 30, 1959. Marine Park, Brooklyn, New York. The writer hesitated for quite some time before proposing a field trip in Brooklyn, and even then it was a tentative suggestion to the chairman of the field committee to use only if he had need to fill out the schedule. The leader would have been pleased if four or five people turned up. When the group finally assembled at the bus stop opposite the entrance to Floyd Bennett Field and turned west toward the beach, fifteen people dragged out notebooks and other botanical paraphernalia, heading straight for a tangled jungle of ragweed more than waist-high. Two or three of the ladies viewed the scene with something less than enthusiasm and wondered if we had to wade through *that*, but they gamely followed the more adventurous members who broke a path.

It may at this time be appropriate to make a few remarks concerning the Kings County flora. In December of 1954 the writer obtained from the New York State Museum a list of the plants known to grow in the county. This list admittedly was not complete, but the 335 names on the list summarized all state records of the native flora of Brooklyn. Since 1954 the writer has explored vacant lots, wasteland, roadsides, and shorelines in Kings County in search of plants growing wild, in part to learn how many of the plants on the list were still growing in the county and in part to add to the list of plants known to grow in Brooklyn. Nearly 200 species have been added to the list during this time.

There is some evidence that the character of the Brooklyn flora has changed considerably during the last sixty years. Not one of the six orchids listed for the county has been seen during the past five years. In addition, of the 29 ferns and fern allies on the list, the writer has been able to locate only two. *Equisetum arvense arvense* and *Pteridium aquilinum latiusculum*, both rather tenacious if not aggressive species, still survive. It should be possible to locate at least two others, for both *Thelypteris palustris pubescens*

and *Athyrium filix-foemina angustum* are quite persistent. Strangely enough, *Onoclea sensibilis* is not recorded from Brooklyn; it has been collected from every other county on Long Island.

A large proportion of the 200-odd species added to the Kings County list consists of European or cosmopolitan weeds. This does not necessarily mean that they have not been growing in Brooklyn during the past sixty years, although some of them, such as *Bromus japonicus*, have undoubtedly been of comparatively recent introduction; this plant was apparently first collected in New York State near Rochester in 1922 (House, H. D., *Annotated List of the Ferns and Flowering Plants of New York State*, p. 125). Many of the earlier botanists seemingly were not much concerned with the common weeds. This in many respects is unfortunate, since records of the introduction and spread of weed species have much scientific interest.

One of the species added to the Kings County list, *Atriplex patula littoralis*, was a new record for the state, and several others had not previously been reported for Long Island—at least in so far as shown by state records: *Atriplex glabriuscula, Pyrus communis, Ligustrum ovalifolium, Convolvulus arvensis, Solanum americanum, Anaphalis margaritacea intercedens, Cosmos bipinnatus*, and *Echinops ritro*. Specimens of all except the last have been collected and verified by Stanley J. Smith, senior curator of the New York State Herbarium in Albany.

The area visited on August 30 was the strip of sandy wasteland between Flatbush Avenue and Dead Horse Bay. Seventy species of plants were observed in all, over two-thirds of which were not on the 1954 county list (all except nine, however, had previously been collected by the writer). The first plant to excite general curiosity was a yellow-flowered composite which no one could identify in the field. It turned out to be *Heterotheca subaxillaris* (Lam.) Britt. & Rusby, otherwise known as camphorweed (a name likewise given to *Pluchea*, the marsh fleabane, a specimen of which one of the members brought along for identification). Fernald (*Gray's Manual*, p. 1378) gives southern New Jersey as the northern range for *Heterotheca* along the eastern coast, but it has been observed at Idlewild Airport since 1950 (*Rhodora*, **56**: 182–183), and Joseph Monachino reports having seen it near Sheepshead Bay and in Marine Park as well as on Staten Island (*Torreya* **86**: 65). One species seen, *Erechtites hieracifola*, has not previously been reported from Long Island.

The majority of the plants observed can roughly be characterized as plants of roadsides and wastelands, but a few are characteristic of beaches and salt marshes. An asterisk (*) preceding a name indicates that the species was not on the 1954 list for Kings County and is here reported for the first time. A double asterisk (**) indicates that the writer had not previously seen the species in the county; in other words, the species so marked have been added to the list as a result of the August 30 field trip. Except where otherwise noted, specimens of all the plants observed are in the writer's herbarium and duplicates either have been or will be deposited in the New York State Herbarium in Albany. Common names have been included in the list at the request of several members of the group.

Plants of Roadside and Wasteland

Equisetum arvense arvense (Field Horsetail), **Polygonum convolvulus* (Black Bindweed; Corn Bindweed), ***P. lapathifolium* (Dock-leaved Smartweed), **P. pensylvanicum* (Pinkweed), **P. persicaria* (Lady's Thumb; Heartweed), **Rumex crispus* (Curly Dock), **Chenopodium album album* (Lamb's Quarters; Pigweed), *C. ambrosoides* (Mexican-Tea), *Cycloloma atripliciifolia* (Winged Pigweed), **Salsola kali tenuifolia* (Russian Thistle), **Oxybaphus nyctagineus* (Heart-leaved Umbrella-Wort), **Phytolacca americana* (Pokeweed), **Mollugo verticillata* (Carpetweed), ***Portulaca oleracea* (Purslane; specimen not collected), **Saponaria officinalis* (Soapwort; Bouncing Bet), **Lepedium virginicum virginicum* (Wild Peppergrass; Poor Man's Pepper), ***Prunus virginiana virginiana* (Choke Cherry; specimen not collected), **Pyrus malus* (Wild Apple), ***Cassia fasciculata fasciculata* (Partridge Pea), **Melilotus alba* (White Sweet Clover), **Strophostyles helvola* (Trailing Wild Bean), **Trifolium hybridum* (Alsike; Pink Clover), **T. repens* (White

Clover), ***Euphorbia maculata* (Milk Purslane; specimen not collected), ***Euphorbia marginata* (Snow-on-the-Mountain), **Rhus copallina* (Dwarf Black Sumac), **Oenothera biennis biennis* (Common Evening Primrose), **Daucus carota* (Wild Carrot; Queen Anne's Lace), **Apocynum cannibinum* (Indian Hemp), **Asclepias syriaca* (Common Milkweed), **Convolvulus arvensis* (Small Bindweed), **Datura stramonium* (Jimson-Weed), **Solanum dulcamara dulcamara* (Bitter Nightshade), **Plantago lanceolata lanceolata* (Narrow-leaved Plantain), ***P. major* (Broad-leaved Plantain; specimen not collected), **Cichorium intybus* (Chickory), *Lactuca canadensis* (Wild Lettuce; Tall Lettuce), **Achillea millefolium* (Yarrow), **Ambrosia artemisiifolia artemisiifolia* (Common Ragweed), * *A. trifida* (Great Ragweed; Buffalo Weed), **Artemisia vulgaris* (Common Mugwort), *Aster ericoides* (White Heath Aster; Frost-Weed Aster), **Cirsium arvense* (Bull Thistle), **Conyza canadensis* (*Erigeron canadensis;* Horseweed; Butterweed), ***Erechtites hieraciifolia* (Pilewort; Fireweed), **Gnaphalium obtusifolium* (Cudweed; Sweet or White Balsam), *Helianthus annuus* (Sunflower), **Solidago graminifolia* (Fragrant Goldenrod; Flat-topped Goldenrod), **S. tenuifolia* (Narrow-leaved Goldenrod), *Bromus tectorum* (Downy Chess), *Cenchrus longispinus* (Field Sandbur), *Digitaria sanguinalis* (Crabgrass), **Echinochloa crus-galli crus-galli* (Barnyard Grass), *Eragrostis megastachya* (Stink-Grass), *E. spectabilis* (Purple Lovegrass), *Panicum dichotomiflorum dichotomiflorum* (Fall Panic-Grass), **P. virgatum spissum* (Switchgrass), *Setaria pumila* (*S. lutescens;* Yellow Foxtail Grass), *Cyperus filiculmis* (Slender Umbrella-Sedge) *C. strigosus* (Strawcolored Umbrella-Sedge).

Plants of Beaches and Salt Marshes

Myrica pensylvanica (Bayberry; Candleberry), **Salicornia europaea* (Glasswort; Chickenclaws; Pigeonfoot), **Cakile edentula* (Sea-Rocket), ***Hudsonia tomentosa* (Beach-Heath), *Solidago sempervirens* (Seaside Goldenrod), *Ammophilia breviligulata* (Beachgrass), **Phragmites communis* (Common Reed; Reedgrass), *Spartina patens* (Salt-Meadow Grass), *Scirpus americanus americanus* (Three-Square; Swordgrass; Chair-Maker's Rush).

In conclusion, the writer invites correspondence with anyone interested in studying the flora of Kings County. Informal field trips can be arranged, and a check list of the Brooklyn flora is available. Leader, Karl L. Brooks.

Book Reviews

The Orchids: a scientific survey. Edited by Carl L. Withner. 648 p. illust. Chronica Botanica No. 32. The Ronald Press. 1959. $14.00.

The first impression of this book is a good one, and this impression is not diminished by a careful reading of each chapter. Although labeled a scientific survey, this book, which is a milestone in orchidology, should prove of great interest not only to researchers but to growers and breeders as well. The bibliographies alone are worth the price of the book.

In Chapter 1, in tracing the early history of orchidology, Withner has assembled an extraordinary amount of Oriental history and folklore regarding these plants. To those of us whose orchid world usually revolves around Latin American Cattleyas, Brassias, Oncidiums, and other delightful genera, it is surprising to find that these are brash newcomers when compared with the Cymbidiums which Confucius enjoyed 500 years before Christ.

The ancient history of orchidology is so thoroughly treated by the author that one scarcely realizes the omission of at least two interesting phases; one of which is the period of intense and very competitive exploration for orchids during the last century which forms a romantic and highly exciting era in the history of orchidology.

The botanical expeditions sent out from Europe, especially from England, to Asiatic and Latin American countries resulted in an explosive development of interest in orchids

and resulted in the assemblage of large collections. The exploration of some of these men deserved to be noted, such as that of Skinner, Bonpland, and Warscewicz in Latin America; and Wallich, Lobb, Griffith, and Hooker in Asia. The names of all of these men are perpetuated in orchid literature and nomenclature. Although they, as well as many others, contributed greatly to orchidology through their collections, it is of interest to note that the great orchid collector, George Ure Skinner, for whom Bateman named *Cattleya Skinneri*, was the first to introduce a living plant of an *Odontoglossum* into England.

Another phase that would have been enlightening to the hosts of New World orchid enthusiasts is the *how* and *why* of the development of a great orchid center in the United States during the turn of the century. The transfer of entire orchid collections from England to North America and the establishment of great private collections and commercial establishments, with the resultant dissemination of orchid plants to thousands of amateurs, makes an interesting story.

Altogether, however, Withner provides the reader with a store of information that would be much more difficult to ferret out than that which is noted above. He has made a most worthwhile contribution in delving through ancient tomes.

In Chapter 2 Schweinfurth has given a most concise and critical summary of the history of orchid taxonomy, to the extent that there is little that one can add. He has ably placed in a few pages not only all the important scientists who have struggled with the classification of orchids, with an analysis of their contribution, but also the lesser ones who have dealt merely in floristics. The fine Bibliography is a handy reference to the general literature on orchids as well as that which treats various regions of the world. The exclusion of one of the more recent books, "Wild Orchids of Britain," by V. S. Summerhayes, was apparently due to an oversight.

In Appendix I, Schweinfurth has produced what might be termed a "long-awaited" key to the orchids in the English language. It is a translation of Schlechter's key from the Latin with, as the author states, "some additions, the elimination of non-contrasting characters, and with a few changes dictated by expediency or current opinion." As he points out, Schlechter's system of classification has several distinct advantages. The key is strictly dichotomous and incorporates the reproductive structures emphasized by Bentham and Hooker (after Lindley) with the vegetative structures advanced by Pfitzer. Also, because it is the most recent classification proposed, it necessarily includes a greater amount of material and a larger number of generic concepts than previous systems of classifications. Since the branches of the key terminate in Subtribes, with a listing of the genera thereunder, it leaves much to be desired. It is regrettable that, with his experience and wisdom, the translator could not have made the further separation to genera under each Subtribe. Even the interpolation into Schlechter's key of the generic keys of Bentham and Hooker would have been exceedingly helpful. Since time is of an essence, the author doubtless felt more disposed to leave such emendations to future generations of orchidologists.

In Chapter 3, Sam Shushan describes the developmental anatomy of *Cattleya* × Trimos. The sequence from seed to maturity is adequately described to give a general picture of the developmental pattern in this hybrid. The extent to which this pattern might hold for other orchids is also briefly discussed. The main contribution of this chapter is that it shows the need for thorough studies on representatives of several of the various sections of the family in order to provide a safe basis for evaluating the family as a whole.

Mrs. Adams' primary theme in Chapter 4 is that variation is the most constant characteristic in the Orchidaceae. Not only is it to be expected but it is apt to be sudden (mutative) and not evolved over a long period of time. She includes 61 plates of figures to demonstrate her theme of variation. The drawings are mostly of individual species rather than of variations within a given species. More drawings showing floral variations within a species might have been included, especially since most orchid enthusiasts already know that orchids, even in their simplest form, are usually complex and oftimes bizarre.

Mrs. Adams states that one of the functions of her contribution "was to experiment with the idea that inherited variations of a basic growth pattern might explain the

variability of the orchid lip more accurately than the theory of its being a compound structure.' It would appear that the subject still remains in the province of speculation since no solution is proposed.

The author has handled rather deftly a most difficult and complicated subject. If the reader studies her drawings carefully, a better understanding of orchid floral morphology will be gained.

As is to be expected in a book where separate chapters are contributed by different authors, some repetition has occurred. In most instances, the repetition was necessary in order better to clarify the subject matter under consideration.

In Chapter 5, Michael Wirth and Carl L. Withner have summarized the available information pertaining to embryogeny and seed development in the orchid family. The authors point out the fact that studies in this field have covered too few species to provide an adequate measure of the variation in this polymorphic family, such as would be required before this information could be used effectively in taxonomy and phylogenetics. Even so, the data given in this chapter should prove useful to the orchid grower and breeder and certainly impress researchers with the vast opportunities in this field.

Robert E. Duncan has done a thorough job in Chapter 6 on cytology of orchids. Of particular interest is the historical account of the role various orchids have played, not only in the development of cytology as a separate discipline, but in the fields of embryogeny and development as well. The more recent cytological studies aimed at facilitating the production of desirable types through breeding is well covered. A very extensive bibliography enables one to locate most papers concerned with any particular area of orchid cytology.

This bibliography may prove of particular interest in connection with the list of chromosome numbers published as Appendix II. Here, unfortunately, a few glaring errors have crept in which might lead to erroneous conclusions, unless the original papers are consulted. Furthermore, an evaluation of the chromosome numbers in this list, in terms of their trustworthiness, or reasonableness, would also have been of great help to the prospective breeder.

Lee W. Lenz and Donald E. Wimber have done a good piece of work in Chapter 7, considering the scarcity of trustworthy information pertaining to several aspects of orchid inheritance. Consequently, they have devoted the greater portion of the chapter to discussing breeding systems and potentials that might be realized if the available information, however meager, is properly used. This chapter should prove of great interest to anyone who is contemplating breeding of orchids, not only from a selfish practical point of view but, even more important, from the point of view of what additional work should be done to furnish some of the many missing links in the chain of knowledge required to bring orchid breeding up to date.

Appendix IV gives a brief account of smear techniques that have been successfully employed in determining chromosome numbers in orchids. Probably no two persons would use exactly the same procedure even when following the same schedule, since making good smear preparations is as much an art as a science but, as a starting point, the schedules presented in this chapter should be helpful to both beginners and experienced technicians.

The physiology of the orchid family, which "is found in a greater variety of habitats than any other plant family," is handled in an interesting and not too technical manner in Chapter 8, by Dr. Carl Withner, who has conducted extensive studies on orchids at Yale University and at Brooklyn College. In it, the author places major emphasis on seed germination and reproductive physiology. An extensive list of references is included.

Chapter 9, Mycorrhiza of Orchids, is written in a most authoritative and a fascinating style by the pioneer in this field, Professor H. Burgeff, of Germany. The historical development of this chapter, together with its illustrations and thoroughness of treatment of the subject, should appeal to most orchid enthusiasts.

Photoperiodic and temperature responses are discussed by Dr. Gavino B. Rotor, Jr., based largely on his research at Cornell University. This chapter provides a concise review of photoperiodism. The practical application of photoperiodism and temperature in the control of flowering in different genera and species of orchids is discussed. Some of the generalizations presented in Chapter 10, however, are open to question.

In Appendix III, Dr. Withner has brought together a wealth of various formulas used for seed germination and for nutrient solutions applicable to orchid culture. Many workers will appreciate the convenience of this extensive source of information, the like of which is not to be found anywhere in orchid literature.

The three chapters dealing with diseases and pests by University of California staff members are the most comprehensive and most practical ones this reviewer (P. P. Pirone) has yet seen.

Peter A. Ark, Professor of Plant Pathology, very ably handles the fungal and bacterial diseases and their control. Excellent illustrations accompany the discussion. Also included in this chapter are ways of curbing algae growing on pots, a problem all orchid growers have to face at one time or another. In a few instances the fungal nomenclature is not up-to-date. For example, *Sclerotium rolfsii* is now *Pellicularia rolfsii* and *Erwinia carotovora*, *Pectobacterium carotovorum*. These, of course, are of no importance to orchid growers or fanciers.

D. D. Jenson, Professor of Entomology, prepared the chapter on Virus Diseases. In addition to presenting a most exhaustive table of the 32 virus diseases known to affect orchids, he gives a very concise and easily understandable explanation of viruses in general. Excellent illustrations depicting symptoms of some virus diseases also accompany this chapter.

A. Earl Pritchard, Associate Professor of Entomology, describes the animal pests of orchids including mites, insects, slugs, and snails. The most commonly available control measures are also given.

The three chapters on pests and diseases alone are worth the price of this book.

Vanilla, its history and culture are thoroughly covered in a very interesting style by Dr. Childers, Cebes, and Hernandez Medina. Much of the contents of this final chapter is based on the results of the authors' work at the Federal Experiment Station at Mayaguez, Puerto Rico. The chapter emphasizes the commercial production of vanilla, and is concluded with a discussion of the chemistry of vanilla.—

DONOVAN S. CORRELL, Texas Research Foundation
O. WESLEY DAVIDSON, Rutgers University
GUSTAV A. L. MEHLQUIST, The University of Connecticut
P. P. PIRONE, The New York Botanical Garden

Carl Linnaeus. Species Plantarum. A facsimile of the first edition, 1753. Volume II, with an appendix by J. L. Heller and W. T. Stearn. London: printed for the Ray Society. 1959. £3 [$8.40].

This completes the work*; it begins just where Linnaeus' original second volume began. But it contains, besides a brief preface by the editor (Stearn), and a rather long list of addenda and corrigenda to his Introduction in volume I, an appendix of 148 pages. Half of this is devoted to a masterly bibliography, by John Lewis Heller, of the works cited by Linnaeus. Since these appear in the *Species plantarum* only as cryptic abbreviations, this part of the Ray Society edition will be of very great value to taxonomists, bibliographers, and historians. Every abbreviation of person or title used by Linnaeus is listed, with the full name and dates of the author, the titles of his works, and bibliographic notes. The remainder of the appendix is devoted to notes on the illustrations used, to an account of four other works of Linnaeus which supplement the *Species*, and finally to an "Index to Classes, Genera and Species" of the entire work. Linnaeus himself had three indexes, one for genera, one for synonyms (of the generic names only), and one for trivial names (including only substantives). Of these only the first has been generally serviceable. Several botanists have indexed the *Species plantarum*, but this, I think, is the first that appears within the same covers as the text to which it refers.

From these brief notes it will appear that this edition of a botanical classic is an

* See Bull. Torrey Club **85**: 491, 492 (1958).

indispensable tool for the taxonomist. The appendix noticed above will certainly help the monographers. The introduction, previously reviewed in these pages, is of value not only to the taxonomist but to any one who wants to use botanical names with some understanding. Every teacher of botany, particularly, should study it.—H. W. RICKETT.

A California Flora. By Philip A. Munz, in collaboration with David D. Keck. 1681 pp., numerous illustrations. University of California Press, Berkeley, 1959. $11.50.

This flora fills a need which has been felt more and more in recent years among students of West Coast botany. No manual of the vascular plants of California has been completed since 1925, when Jepson's "Manual of the Flowering Plants of California" was published. Since that time extensive taxonomic work has been done, with the result that not only many new plant species have been found within the state, but through investigations in such related fields as cytology, genetics, ecology, etc., new concepts have been formed of the relationships of already well-known entities.

Both authors are highly competent in the field of taxonomic botany. Dr. Munz brings to this work the experience of a lifetime of study on the California flora. For many years he was Professor of Botany at Pomona College. Since 1947 he has been Director of the Rancho Santa Ana Botanic Garden at Claremont. His previous publications include monographs and revisions in several plant genera, particularly in the *Onagraceae*, and a manual of Southern California botany. Dr. Keck was formerly on the staff of the Division of Plant Biology of the Carnegie Institution of Washington, first at Berkeley and later at its laboratory at Stanford, where he was associated with the program of experimental taxonomy. More recently he has been Head Curator of the Herbarium of the New York Botanical Garden. His own monographic work includes publications in the *Madiinae* and in *Penstemon*.

The present flora is a striking expression of the concept among taxonomists that species are, above everything else, dynamic things, and that it is the function of the taxonomist not only to distinguish among them by their morphological features, but also to recognize what has been their reaction to the environment in which they are found and their present relation to the major units of the flora with which they are associated. This is not entirely a new departure, since monographic works of the past several years have tended to stress the ecological viewpoint of the taxa treated, and one other West Coast flora now appearing (Hitchcock and others, "Vascular Plants of the Pacific Northwest") approaches the taxonomy of its species from this angle. However, this is the first completed flora covering a territory as extensive as the state of California with its many vegetation types and great number of plant species to emphasize this approach. This is the outstanding feature of the manual and its most notable contribution, in the opinion of this reviewer. The ecological viewpoint is reflected, among other ways, in the way in which species ranges are cited. In addition to the usual geographic limits of the entity the authors list for each one the plant community or communities with which it is most commonly associated, such as Chaparral, Valley Grassland, Northern Oak Woodland, etc. These communities were first presented in a previous publication by the authors (California Plant Communities, El Aliso **2**: 87–105, 1949, and **2**: 199–202, 1950). They are summarized again in the introduction to the present flora. The discussion includes climatic and other ecological data for each one, general appearance of the community, and a list of indicator-species. It is an extremely useful classification of California vegetation and should have applications far beyond this manual.

The authors are conservative, in the parlance of the taxonomist. They choose to place relatively heavy emphasis upon the similarities among populations rather than upon their differences, and tend to interpret their observations to mean that closely related entities are frequently simply members of a single wide-spread species which has split up into subspecies under the influence of varying environments and of isolation. The expression of this concept in the manual results in a smaller number of species, many of which have a rather large number of subspecies.

The authors have departed markedly from the system of classification to which we have long been accustomed in floral manuals—the system adopted by Engler, and the one according to which most of our herbaria are arranged. They have made these changes in keeping with the more modern views on the natural relationships of plant groups, resulting from recent investigations in morphology, anatomy, serology, etc. The newer classification begins with the major groups of the vascular plants, the Divisions—of which there are five: *Lepidophyta, Calamophyta, Pterophyta, Coniferophyta,* and *Anthophyta,* and goes on down through the other categories. So far as the ordinary use of the manual is concerned, the most obvious change is in the order in which families occur in the book. Some of us will have to have recourse to the index for a time, while we are becoming familiar with the system that the authors have used; that slight inconvenience may afford us the opportunity to mull over the reasons lying back of it all. In addition to modifications in the order of arrangement we find such changes as the splitting of the *Polypodiaceae* as we usually conceive of them into five families. This is a classification long considered logical by many botanists but which the writers of manuals until now have never gotten around to incorporate into their work. Then at the generic level we may be puzzled momentarily when we search through the*Liliaceae* for *Allium* or *Brodiaea,* only to locate them finally in the *Amaryllidaceae.* These are just a few examples of the type of changes we meet with.

A brief but very useful account of the geological history of the California flora contributed by Daniel I. Axelrod, is included in the introduction. It follows the migrations and evolution of the three geofloras which during the Tertiary contributed to the floras of the southwestern United States, and furnishes an enlightening background for the study of present-day floristics in California.

The usefulness of the manual for the student of West Coast botany is further enhanced by several features incorporated in the text. The description of each plant family is supplemented by drawings illustrating its more important diagnostic floral and vegetative characters. The drawings are based upon species common in the California flora. The treatment of each genus is prefaced by the citation of any significant monographic or other revisionary treatment where such studies have been made, thus bringing the user of the manual up to date in the literature of the genus. Also, preceding each species description is listed the significant synonymy of that species. All the synonyms are very conveniently listed in italics in the general index. Finally, we should mention the keys to the identification of subspecies, so frequently omitted from manuals; here they are included whenever the number of such subspecies within a species is sufficient to justify their use.—LeRoy E. Detling. University of Oregon, Eugene.

Cell, Organism and Milieu. Edited by Dorothea Rudnick. vi + 326 pp. The Ronald Press, New York. 1959. $8.00.

This book represents the papers presented at the Seventeenth Growth Symposium held at Mount Holyoke College in June, 1958, dealing with the general subject: "Differentiation and growth in response to a changing chemical environment." Although only two of the ten papers deal with plants the series represents a consistent whole which makes it valuable to any biologist.

Wilde begins by discussing the role of specific chemicals, particularly phenyl-alanine and its related substances, in the differentiation of two specific types of cell, the muscle cell and epithelial pigment cell. Hoffman-Berling continues this with a curiously eerie study of the effect of the specific muscle activator, ATP on the dead ghosts of fibroblasts, which contract, relax and even divide when properly treated. Nason and Vasington's investigation of tocopherol in muscle is even more unbiological in the sense of being strictly a test-tube study of extracts, not even of the ghosts of cells. Csapo's treatment of the myometrium is more theoretical yet has a little more reality in attempting to tie together the many problems of regulation as they exist in living organisms, and Moog's researches on phosphatases in specific tissues and their chronological development from embryo to adult comes back still further toward the living whole. The last paper, by Lutwak-Mann

on the physiology and biochemistry of the mammalian blastocyst belongs pretty much in the same category.

There remains the portion of interest to botanists which nevertheless includes some far from botanical material. The sixth paper, by Schneidermann and Gilbert on insect growth hormones I can recommend to anyone as a model, not only in the presentation but in the planning of the research. A series of clear, simple, straightforward questions are answered by well planned experiments, lucidly presented. The effect of application of a trace of purified abdominal wax to the developing thorax of a pupa in metamorphosis is dramatic and convincing, and the ubiquity of the substance involved speaks for its importance. Torrey's paper on modifications in the development of roots and on chronological shifts in chromosmal patterns is in the same vein. Luckwill's paper on the chemical stimuli involved in fruit growth is somewhat more general but equally important. And finally Loomis gives a fascinating discussion of the role of internal CO_2 tension in controlling the expression of sex in the simple invertebrate *Hydra*. This factor probably has much wider significance than has been generally recognized.

Besides Torrey's and Luckwill's papers I would particularly recommend those of Schneidermann and Gilbert and of Loomis. Whatever one's personal field of research these two papers, as examples of how research should be conceived, carried out, and presented, are worth the price of the volume, which keeps up the long recognized tradition of excellence of its predecessors.—PHILIP R. WHITE, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

Developmental Cytology. Edited by Dorothea Rudnick. vi + 215 pp. Ronald Press. 1959. $7.00.

"Developmental Cytology" represents the contributions, from a number of biologists active in various areas of research, to the sixteenth symposium of the Society for the Study of Development and Growth. Although the coverage can not be comprehensive in a small volume, the topics selected are appropriate and the material covered is at the frontiers of the science in many cases.

Preer gives an interesting summary of the information on self-reproducing entities in the cytoplasm of protozoa with particular reference to *Paramecium*. About one-half of the article is devoted to the inheritance and control of the immobilization antigens. Partanen considers the problem of quantitative changes in chromosomes and DNA (deoxyribonucleic acid) in relation to differentiation in normal development and in plant tumors and tissue cultures of plants. Hsu considers the same topic for animal tissues, tissue cultures and neoplasms. Klein and Klein summarize studies on antigenic properties of tumor cells as compared to normal host cells and review some of the studies on the chromosome cytology of neoplastic tissues.

Beermann reviews the work on chromosomal changes during the development of insect larvae. Particular attention is given to growth and development of polytene chromosomes of Diptera. Variations at specific loci in different organs and in different functional regions of the same organ are shown in relation to development. The variations which appear in the band patterns often are puffs or enlargements which he interprets as indications of enhanced activity of the genetic loci. Since the variations are reversible, the genetic material of the different cells does not appear to be permanently changed during differentiation.

Stich reviews some recent observations and experiments on the relation between chromosomal loci and the formation of nucleolar substance and interrelations between the nucleolus and cytoplasmic activity especially with respect to protein and nucleic acid synthesis.

Wettstein considers the latest information available from electron microscope studies of the chloroplast. Fine structural changes during differentiation and division of plastids give considerable insight into problems of their mode of formation, origin and their ability to transmit their genetic properties. Fawcett reviews recent observations on the changes in fine structure of other cytoplasmic organelles during differentiation.

Mitochondria, endoplasmic reticulum and the Golgi complex are the center of focus in special types of cells including the cnidoblasts of hydra which produce the specialized minute projectiles, nematocysts.

Finally the localization of metabolic systems in cell fractions by biochemical methods is considered briefly by Lehniger.

All of the articles are well written. The authors and the editor are to be congratulated on an interesting and useful volume. Teachers and workers in related fields will find it brings them up to date and graduate students will find it a valuable source for summaries of the latest work and references to more extensive treatments.—J. HERBERT TAYLOR, Columbia University.

Vegetational History of the Ozark Forest. By Julian A. Steyermark. University of Missouri Studies, vol. 31. viii + 138 pp. Univ. Missouri Press, 2 Lathrop Hall, Columbia, Missouri. 1959. $2.00.

For nearly 35 years, Julian Steyermark has studied and published on the flora and vegetation of the Ozark Region. With his field studies as a background and with a thorough familiarity with the literature of the region, Dr. Steyermark has enquired into the history of the forest flora of the Ozarks. His approach to the subject is interesting in that it is first a literature survey and summary of field studies aimed at the development of the thesis that the present forest flora of the Ozarks is of great antiquity and it is secondly a thorough and painstaking dismemberment of the works of other recent authors who have attempted to determine the pre-settlement vegetation of the Ozarks.

The geological history of the Ozark Region, which has been a land area continuously since the close of the Paleozoic era, is briefly summarized on the first page and a half. Then the author presents a series of selected vegetation descriptions from early government records, historical publications, and travel accounts. On pages 23 through 59, he launches a literary blitzkrieg that completely devastates a theory championed by August P. Beilmann and Louis G. Brenner that, at the time of settlement, the Ozark Region was a prairie or parkland. The initial attack rips at the historical data quoted by these two authors and then the heavy artillery emasculates their interpretations of soil data, early observations on game birds and mammals, honey bee invasion, climatic data, changes in the dimensions of the Mississippi River, the disappearance of salt licks, the location and abundance of post roads, the effects of fire in the Ozarks, and the present commercially immature condition of forests in the Region.

A third section compares present-day forests with the descriptions of the land surveys and other early records. In summary, these data indicate that, "no definite change in the composition of the original forest cover and distribution of the forest pattern in the Ozark area can be shown to have taken place. What is prairie now was prairie then, what is forest today was forest then." Dr. Steyermark also discusses the present and former status of the red cedar, hawthorn, and "underbrush" vegetation and cites data from the land surveys to prove that the early Ozark forests contained occasional large trees. In each of these subsections, the author drops a few more well-placed bombs on the remains of Beilmann and Brenner's "prairie and parkland" theory. He terminates the section with selected quotes from the survey records to describe and locate the "unglaciated prairie province of western Missouri" and the prairie openings.

The final section of the monograph is devoted to a discussion of "Present distributional patterns and their long development." Here, Dr. Steyermark discusses endemics, paleobotanical history, and special habitats of the Region.

In summary, "Vegetational History" is a well-documented, convincing treatise, written by an outstanding student of the Ozark Region. Its style is difficult and unpolished, but as one reads he begins to share with the author a feeling of excitement as a target theory is set up and then riddled with bullets of contradicting data until at last the target has disintegrated and the bullets have fused into a new, more realistic theory.—JACK MCCORMICK, The American Museum of Natural History, New York.

NOTES

Professor Charles A. Berger, Fordham University, terminated his service as editor for the Torrey Botanical Club with the completion of volume 86, 1959. Assuming the editorship with the July 1949 number, Dr. Berger has seen ten and one-half volumes through the presses and into the mails. Consider the manuscripts to be read, authors to be consulted, and the deadlines to be met! This was on top of a teaching and research schedule as well as administrative duties at the University.

The editorial responsibility has been transferred to Rutgers, The State University of New Jersey. It is proposed to be a Department of Botany responsibility and for the present Professor Murray F. Buell will serve as acting editor. Also for the present, Torreya and the non-manuscript facets of Bulletin production will go on as before.

This is a return engagement for the Bulletin at Rutgers. It was edited here by Professor M. A. Chrysler, 1934–1938.

Professor James E. Gunckel, Chairman of the Department of Botany at Rutgers is doing research at the Station Centrale de Physiologie Vegetale in Versailles, France. Dr. Gunckel is a Waksman Foundation Fellow.

Professor H. M. Chute has become Emeritus Professor of Botany at Douglass College, Rutgers, and Dr. Charlotte J. Avers, formerly of the University of Miami, Coral Gables, Florida, has joined the Douglass College group. Dr. Avers' responsibilities will be in genetics and related fields at the State University.

Professor Curtis M. Wilson has transferred from the Department of Plant Physiology, College of Agriculture, at Rutgers, to the Department of Botany at University of Illinois. Dr. Carl Price, formerly at Harvard University, has been appointed as successor to Dr. Wilson.

Also at Rutgers, the staff of botany has been expanded by the appointment of Dr. Richard Smith, formerly of Miami University, Oxford, Ohio.

A biology building, with a spacious wing for the Bureau of Biological Research, is being erected at Rutgers, the State University of New Jersey. Target date for completion is June 1961.

Dr. Sydney Greenfield, Professor of Botany at the Newark College of Arts and Sciences of Rutgers, has assumed the editorship of Plant Science Bulletin, published by the Botanical Society of America.

Professor Robert Lampton is now in the Department of Biology at Fairleigh Dickerson University, Rutherford, N.J.

Professor Elva Lawton has retired from the Department of Biology at Hunter College and moved over to the University of Washington at Seattle. This takes Dr. Lawton well out of the Torrey Range where she has led many field trips and served the Club in so many other capacities in recent years.

Let us have more Notes on personnel activity, departmental achievement, and botanical observation! Time was when botanists enjoyed so putting themselves on record.

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INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF BRITTONIA

TAXONOMY, PHYLOGENY AND FLORISTICS

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